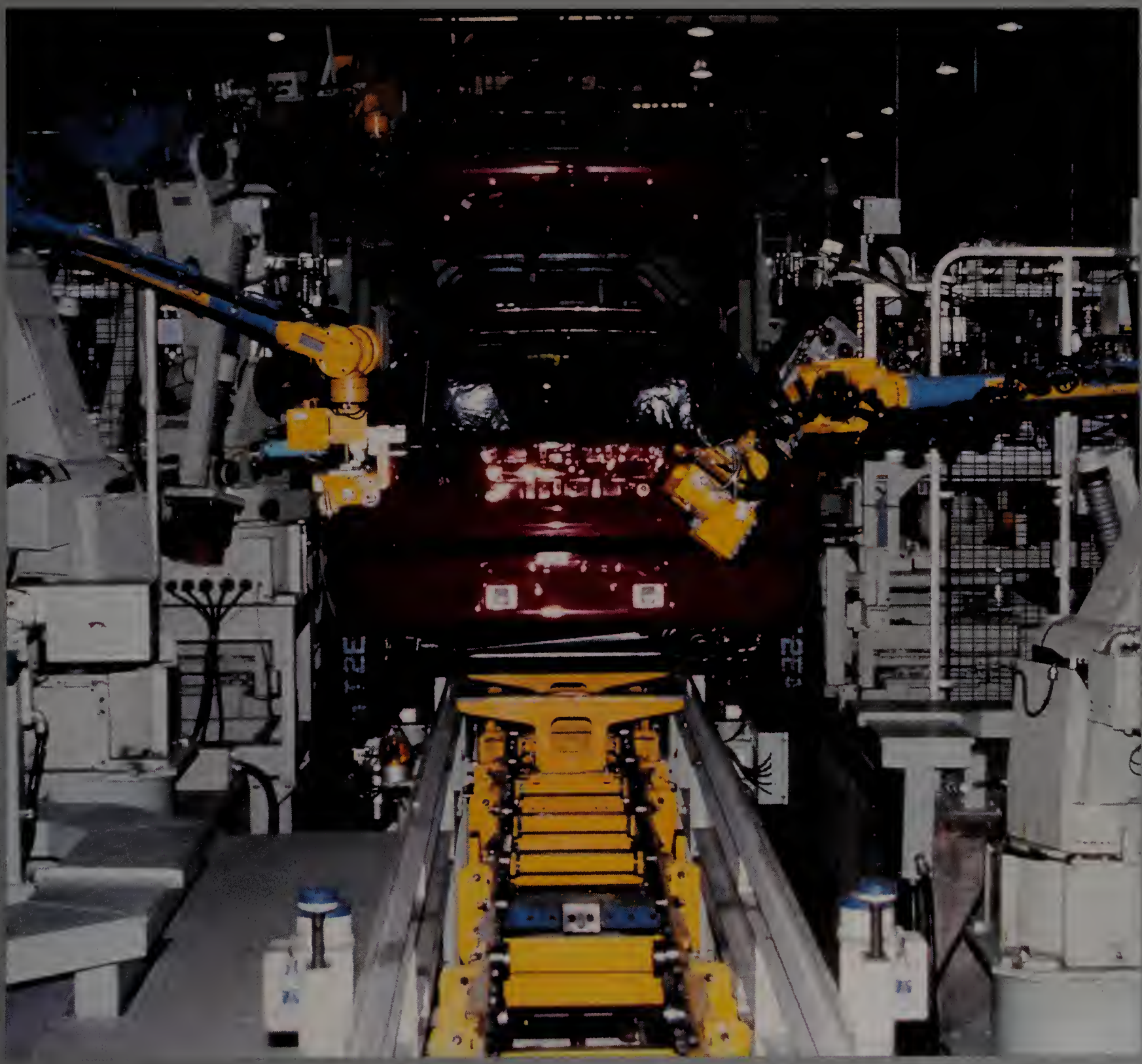
MANUFACTURING
systems

R. Thomas Wright




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MANUFACTURING
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INTRODUCTION

MANUFACTURING SYSTEMS will provide you with many opportunities to study the basic elements of manufacturing as a managed body of activities. These basic elements have been arranged under the two major categories of material processing and management.

Specifically, MANUFACTURING SYSTEMS covers seven areas of manufacturing representing the entire range of manufacturing. These areas are:

- Manufacturing Systems.
- Manufacturing Materials.
- Manufacturing Processes.
- Introduction to Management.
- Manufacturing Enterprise.
- Automating Manufacturing Systems.
- Manufacturing and You.

As you use MANUFACTURING SYSTEMS, you will learn that manufacturing is a managed system that draws upon resources. You will explore a number of material processing techniques common to manufacturing. Then you will find out how activities are managed. Finally, you may apply this newly developed knowledge in a realistic setting–a student-operated manufacturing enterprise. You will be introduced to the concepts of leadership and entrepreneurship while participating in these activities.

MANUFACTURING SYSTEMS is heavily illustrated with photographs, drawings, diagrams, and original artwork, many in full color. This material has been carefully selected to enrich the text.

Each chapter begins with a list of instructional objectives. New vocabulary terms appear in bold. Following each chapter, a list of words to know is given along with review questions covering material presented in each chapter. Several chapter-end activities are also given that will allow you to apply your knowledge.

MANUFACTURING SYSTEMS is a basic text for use by anyone interested in the various career opportunities available in the cluster of manufacturing trades and related jobs. It will enable you to obtain a working knowledge of what people involved in manufacturing do.

An Activity Manual is available for use with MANUFACTURING SYSTEMS. Many of the suggested activities provide you with hands-on experiences. The numerous exercises allow you to practice and enrich the many manufacturing concepts presented in the text.

Manufacturing is an exciting area of study. It is a dynamic area involving action. As you study, you will have opportunities to change the form of materials using material processing techniques. Later, you will study how people manage these activities using resources efficiently. Finally, you will form a company to design, produce, and market a product.

R. Thomas Wright

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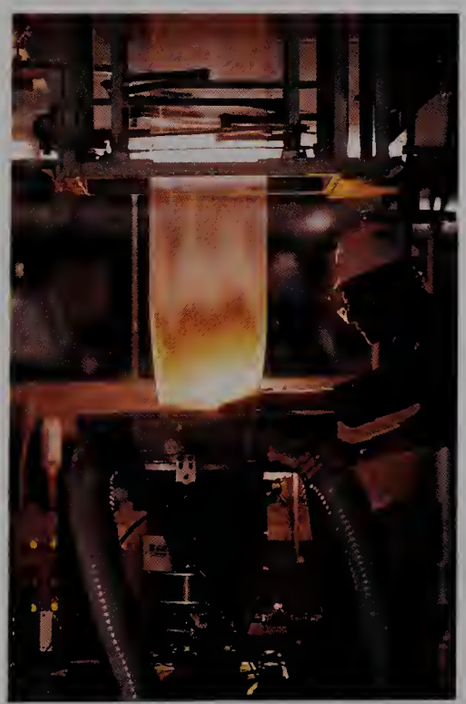
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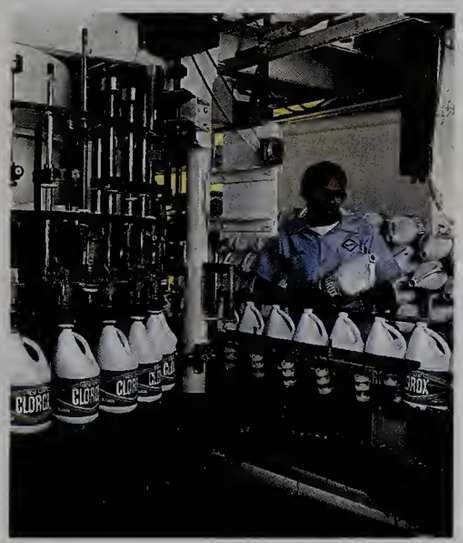
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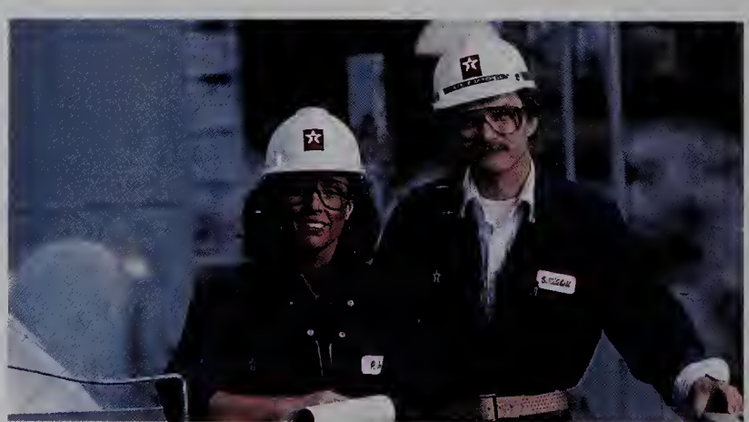
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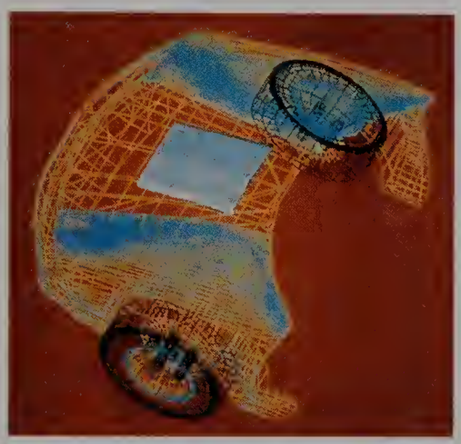
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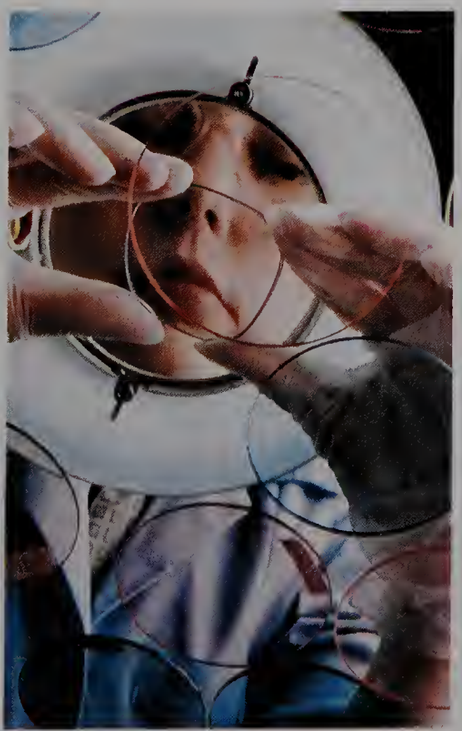
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SAFETY AND MEASUREMENT IN MANUFACTURING

Before you begin the study of manufacturing, it is necessary for you to review a few basic concepts from your earlier classes. These concepts can be divided into two groups: safety and measurement.

SAFETY IN MANUFACTURING

Life is full of hazards. As you move through the day, you encounter situations that could cause harm to you. A car could hit you as you cross the street. You could fall or slip as you climb stairs. However, you can reduce the chance of being hurt by acting responsibly.

Likewise, the manufacturing environment has many hazards. In factories, there are machines and materials being used by people. There are sharp cutters, moving shafts, hot materials, fumes, and many other conditions that could harm workers. The chance of injury can be reduced through thoughtful action. This practice is called **safety.** It is all the actions people take to reduce the likelihood of personal injury. These safety practices can be grouped into three categories. See Fig. 1. The categories are safety with people, safety with machines, and safety with materials.

Safety is a state of mind and a series of actions. A person must be concerned about safety. He or she must make safety a high priority. How often have you seen people driving, playing a sport, moving through a building, or working with a tool without regard for safety? We often say that these people "aren't using common sense." They are not directing their actions in responsible ways.

Safety is also a set of actions. There are ways to safely complete tasks. For example, a football coach teaches players to block safely. There are ways to do the task that reduce the chance of injuries. Likewise, there is a series of practices that can make working in manufacturing safer. Often, these safety practices are communicated through rules. These rules, like driving rules, tell how to safely complete a task.

A list of safety rules will help you review and develop safe work habits. A list of safety rules is given in Fig. 2. You may want to photocopy them so that you will have a set with you as you work on the manufacturing activities in this course. These are general rules, and they apply to many manufacturing settings and many material processing activities. More specific safety precautions will be presented as your teacher introduces each laboratory activity.

Look at Fig. 3. List all the safety measures demonstrated by the mannequin.

Note: Safety equipment shown in this text may have been removed or opened to clearly illustrate the product and must be in place prior to operation.

FEDERAL AND STATE ASPECTS

Both federal and state laws provide guidelines for the safe operation of tools and equipment. Federal safety regulations are covered in the Occupational Safety and Health Act of 1970. This act (law) gave the Occupational Safety and Health Administration (OSHA) the mission "to assure so far as possible every working man and woman in the nation safe and healthful working conditions and to preserve our human resources."

OSHA's functions include setting standards, inspecting workplaces, leveling citations and penalties for violations, consultation, and conducting training and educational programs.



Fig. 1. Safe working involves working safely with people, machines, and materials. (Zero Manufacturing)

SAFETY WITH PEOPLE

PERSONAL SAFETY

1. Concentrate on your work. Watching other people and daydreaming can cause accidents.
2. Dress properly. Avoid loose clothing and open shoes. Remove jewelry and watches.
3. Control your hair. Secure any loose hair that may come into contact with moving machine parts.
4. Protect your eyes with goggles or safety glasses.
5. Protect your hearing by using hearing protectors around loud or high-pitched machines.
6. Do not use compressed air to blow chips and dirt from machines or benches.
7. Think before acting. Always think of the consequences before starting an action.
8. ASK your teacher questions about any operation of which you are unsure.
9. Seek First Aid for any injuries.
10. FOLLOW specific safety practices demonstrated by your teacher.

SAFETY AROUND OTHERS

1. Avoid horseplay. What you consider as innocent fun can cause injury to other people.
2. Do not talk to anyone using a machine. You may distract him or her and cause injury.
3. Do not cause other people harm by carelessly placing materials and tools on benches or machines.

SAFETY WITH MATERIALS

1. Handle materials properly and with care.
   a. Watch long, moving material. Do not hit people and machines with the ends.
   b. Use EXTREME caution when handling sheet metal. The thin, sharp edges can easily cut you and others.
   c. Grip hot materials with pliers or tongs.
   d. Wear gloves when handling hot or sharp materials.
   e. Use extreme caution in handling hot liquids and molten metals.
2. Check all material for sharp burred edges and pointed ends. Remove these hazards whenever possible.
3. Place material that gives off odors or fumes in a well-ventilated area, fume hood, or spray booth.
4. Lift material properly. Do not overestimate your strength.
5. Dispose of scrap material properly to avoid accidents.
6. Clean up all spills quickly and properly.
7. Dispose of hazardous wastes and rags properly.

SAFETY WITH MACHINES

GENERAL RULES

1. Use only sharp tools and well-maintained machines.
2. Return all tools and machine accessories to their proper storage locations.
3. Use the RIGHT tool and machine for the RIGHT job.
4. DO NOT use any tool or machine without permission or proper instruction.

CASTING AND MOLDING PROCESSES

1. DO NOT try to complete a process that has not been demonstrated to you.
2. Always wear safety glasses.
3. Wear protective clothing, gloves, and face shields when pouring molten metal.
4. DO NOT pour molten material into a mold that is wet or contains water.
5. Carefully secure two-part molds together.
6. Complete casting and molding processes in well-ventilated areas.
7. DO NOT leave hot castings or mold parts where other people could be burned by them.
8. Constantly monitor material and machine temperatures during casting and molding processes.

SEPARATING PROCESSES

1. DO NOT try to complete a process that has not been demonstrated to you.
2. Always wear safety glasses.

Fig. 2. Continued on page 12.

Fig. 2. Review these safety rules before attempting any manufacturing activity. Check with your teacher for any additional safety rules to follow.

SAFETY WITH MACHINES

SEPARATING PROCESSES

3. Keep hands away from all moving cutters and blades.
4. Use push sticks to feed all materials into wood cutting machines.
5. Use ALL machine guards.
6. Stop all machines to make measurements and adjustments.
7. Do not leave a machine until the cutter has stopped.
8. Whenever possible, clamp all work.
9. Unplug all machines from the electrical outlet before changing blades or cutters.
10. Remove all chuck keys or wrenches before starting machines.
11. Remove all scraps and tools from the machine before using it.
12. Remove scraps with a push stick.

FORMING PROCESSES

1. DO NOT try to complete a process that has not been demonstrated to you.
2. Always wear safety glasses.
3. Always hold hot materials with pliers or tongs.
4. Place hot parts in a safe place to cool. Keep them away from people and from materials that will burn.
5. Follow correct procedures when lighting torches and furnaces. Use spark lighters, NOT matches.
6. NEVER place hands or foreign objects between mated dies or rolls.

FINISHING PROCESSES

1. DO NOT try to complete a process that has not been demonstrated to you.
2. Always wear safety glasses.
3. Apply finishes in properly ventilated areas.
4. Do not apply finishing materials near an open flame.
5. Always use the proper solvent to thin finishes and clean finishing equipment.

ASSEMBLING PROCESSES

1. DO NOT try to complete a process that has not been demonstrated to you.
2. Always wear safety glasses.
3. Wear gloves, protective clothing, and goggles for all welding, brazing, and soldering operations.
4. Always light torches with spark lighters.
5. Handle all hot materials with gloves and pliers.
6. Perform welding, brazing, and soldering operations in well-ventilated areas.
7. Use proper tools for all mechanical fastening operations. Be sure screwdrivers and hammers are the proper size.

Fig. 2. Continued.

Employers must comply with OSHA standards by providing and maintaining a safe work environment for workers. This means that workers must be protected from job-related hazards and excessive noise levels. A clean work environment as well as proper lighting and ventilation are also required by OSHA.

Sometimes states develop and operate their own job safety and health programs. These programs must be at least as effective as the federal program. In addition to OSHA standards, many states have additional guidelines that must be met.

MEASUREMENT IN MANUFACTURING

All materials have a basic size, shape, or volume. These characteristics can be measured and calculated. This study of manufacturing systems will focus on materials that have a solid structure. These materials, as you will learn, are called engineering materials. In manufacturing, the form of these materials is changed to make them more useful. The materials are reshaped using manufacturing processes. Throughout these processing activities, the size and shape of materials are measured.

Two basic systems of measurement are used worldwide. The one most commonly used in manufacturing is called the SI (International System, or in French, the Systeme Internationale) or metric system. It is based on the meter. This unit is then divided into decimal parts. A centimeter is 1/100 of a meter and the millimeter is 1/1000 meters.

The United States has maintained a separate system called the Conventional system. This system uses the foot as the standard unit. It is divided into twelve equal parts, each of which is called an inch. The inch can be divided into fractional parts. Commonly, we

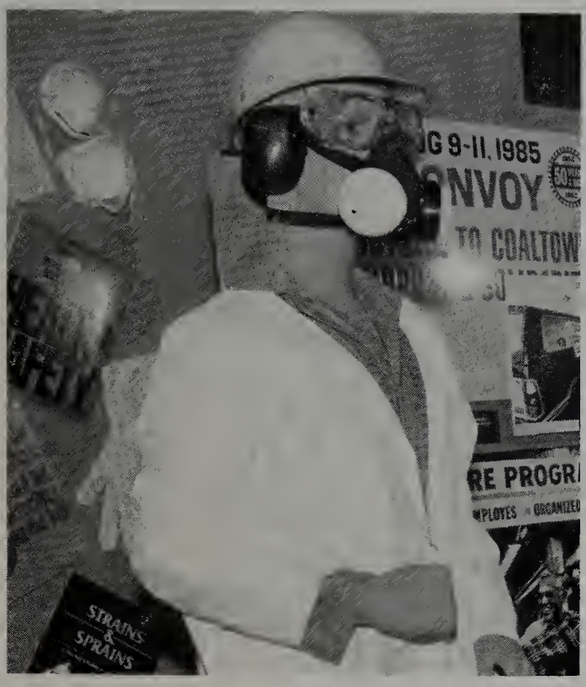


Fig. 3. This mannequin is dressed for safety. (UAW Solidarity)

use quarters (1/4 inch), eighths (1/8 inch),sixteenths (1/16 inch), thirty-seconds (1/32 inch), and sixty-fourths (1/64 inch).

Either of these systems of measurement can be used in the two basic types of measurement. These types, as shown in Fig. 4, are standard and precision.

Standard measurement is widely used in the construction industry, in furniture manufacture, and in sheet metal fabrication. The standard Conventional unit of measurement is the inch and its fractions.

Precision measurement is used for all manufacturing where close tolerances, fits, and dimensional control are required. This type of measurement uses thousandths (1/1000) or ten-thousandths (1/10,000) of an inch.

Directly related to measurement are the names of surfaces and dimensions of a part. These, as reviewed in Fig. 5, are:

- Thickness: The smallest dimension of a piece of material. It is usually the distance between the two sides or faces.
- Width: The second smallest dimension of a piece of material. It is usually the distance between the two edges.
- Length: The largest dimension of a piece of material. It is usually the distance between the two ends.
- Side: The largest surface of a material.
- Edge: Generally, the second largest surface. For wood, it is the second largest surface that does not show end grain.
- End: Generally, the smallest surface. For wood, it is the surface that shows end grain.

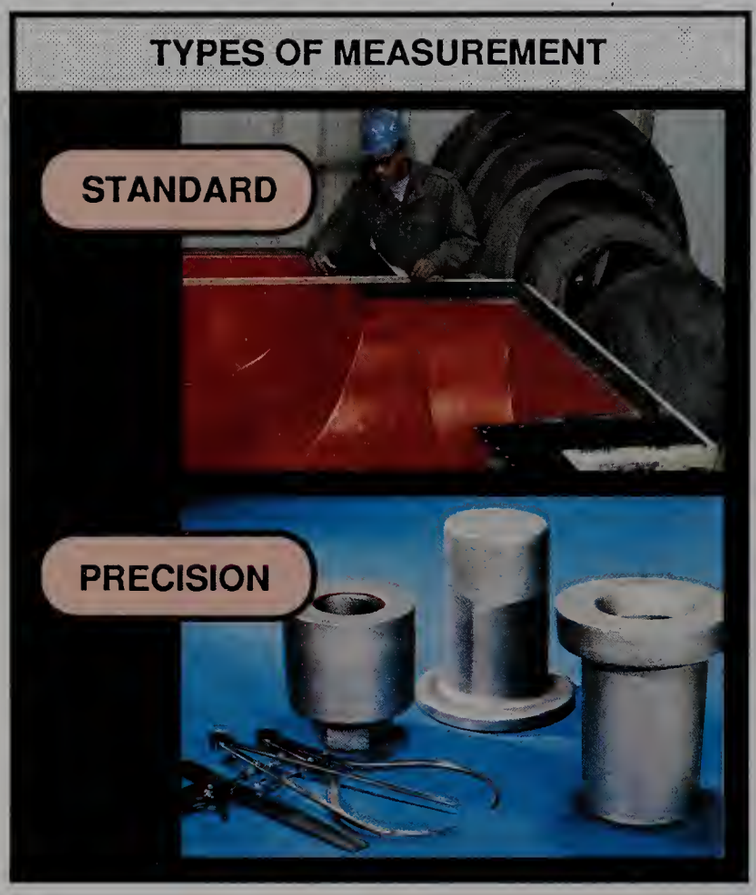


Fig. 4. These are the two basic types of measurement.

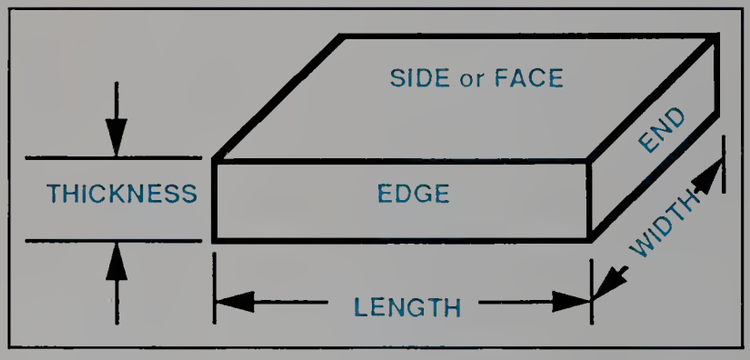
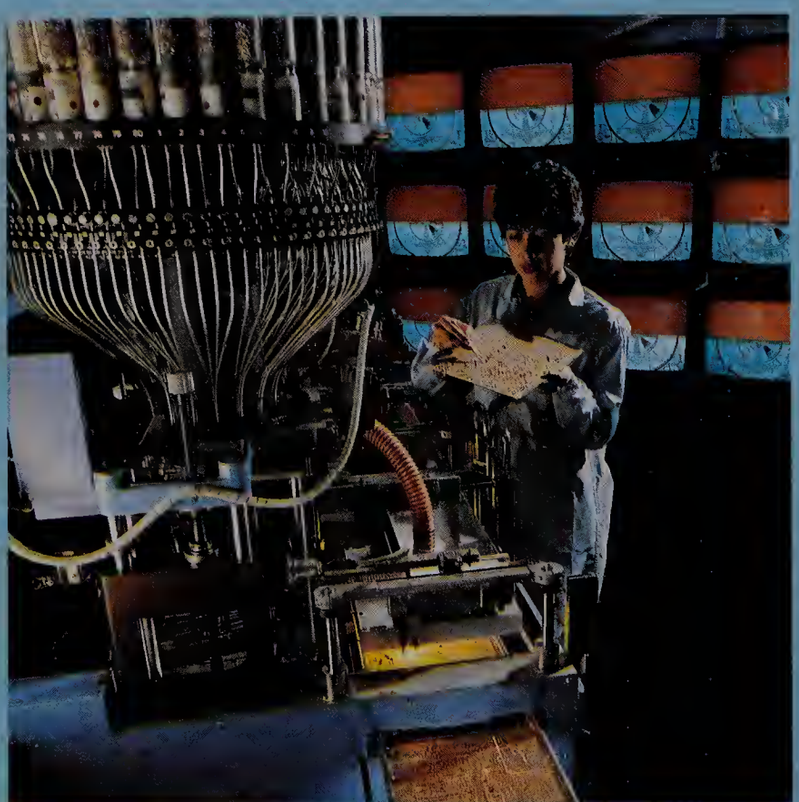


Fig. 5. This diagram indicates the standard names for dimensions and surfaces of a piece of material.

When giving a part size, convention suggests that the thickness is given first. Then the width is given and, finally, its length. Therefore, if a part is said to be 1/2" x 3" x 10", its thickness is 1/2 inch, its width is 3 inches and its length is 10 inches. Also, if there are no measurement marks such as (") for inches or (') for feet, the measurement is understood to be in inches.

To review your knowledge, select several items such as your textbook, laboratory manual, etc. Measure their width, thickness, and length using SI and Conventional measurements.

Now that you have reviewed safety and measurement, you are ready to start a challenging study of manufacturing. Good luck!



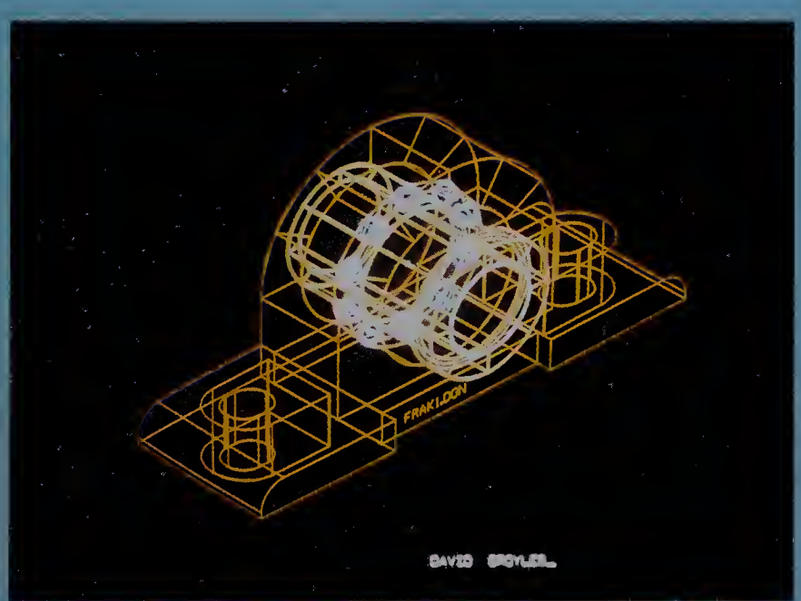
ZENITH



section 1

Manufacturing Systems

1. Technological Systems
2. Manufacturing System Components





GOODYEAR TIRE AND RUBBER CO.



Technology brings us products to make our lives easier. Some of the products are still in designers' minds.
(General Motors Corp.)

1

CHAPTER

TECHNOLOGICAL SYSTEMS

After studying this chapter, you will be able to:

- *List and define the four major groups of knowledge.*
- *Explain how technology has an impact on your life every day.*
- *Define the five essential elements of a technological system.*
- *Give examples of technological systems.*
- *List and describe the four major groups of technological systems.*

You live in a complex world. This world is a combination of natural and human-made components. For instance, look at Fig. 1-1. The trees, water, and sky occur in nature. No human made them. These are all natural elements. The machinery and the building in the background are human-made elements. Unseen, but also important to the view is human will. People felt that it was appropriate to cut these trees because they decided that homes made from lumber were desirable.

MAJOR GROUPS OF KNOWLEDGE

By studying four major groups of knowledge, you will be better prepared to understand the natural and human components of a system. These groups of knowledge are science, technology, the humanities, and descriptive studies, Fig. 1-2.

In studying **science**, you can gain an understanding of the laws and principles that govern the physical universe. You may learn about biology, mechanics, geology, astronomy, and many other topics.



Fig. 1-1. Can you see both natural and human-made elements in this photograph? (Weyerhaeuser Co.)

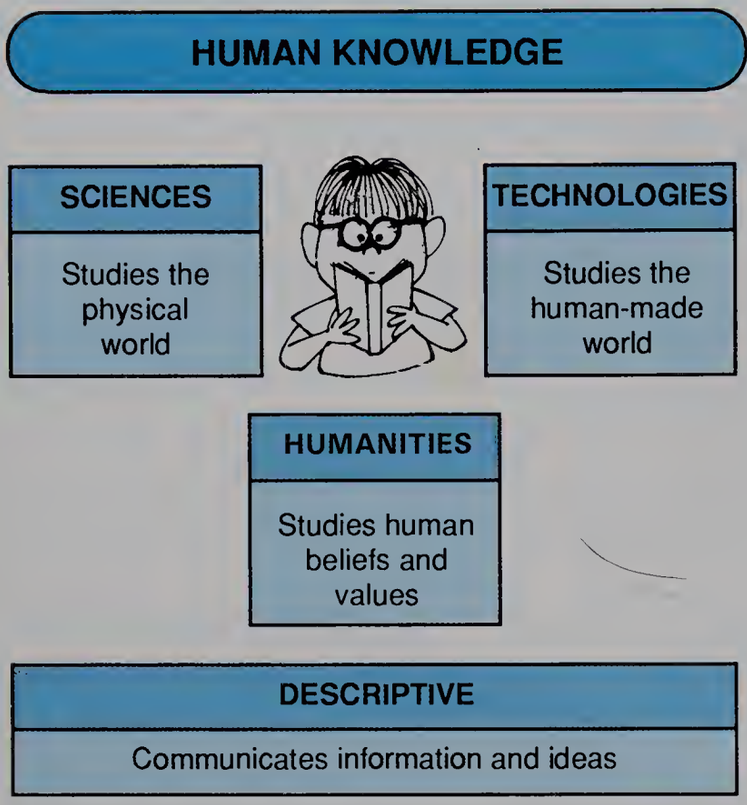


Fig. 1-2. To understand the world around us, we must study four major types of knowledge: science, technology, the humanities, and descriptive knowledge.

For example, refer back to Fig. 1-1. You could use science to learn about the life cycles of the various species of trees. Through science, you would also gain an understanding of the strength of the different types of lumber. The science of mechanics would be used to understand the operation of the log unloader. Specific gravity would explain why logs float.

To find out about the things people have made, are now making, and are likely to make, you would study **technology**. Technology is the study of how humans develop and use communication, housing, tools, vehicles, and thousands of devices that improve the quality of life. The study of technology focuses on how humans design items to change or control the world around them.

Again, related to Fig. 1-1, technology provided the system used to harvest the trees, construct the saw mill, and design and build the log unloader. It also provided the system used to saw the logs into lumber, transport the lumber to a building site, and fabricate it into houses.

The study of **humanities** relates to areas of philosophy and human concern. As people study the humanities, they develop personal priorities. These help to guide a person in deciding what is and is not desirable. For instance, a study of humanities could help you come to some conclusions about the "proper" use of forest lands. You could take a stand on how much of it should be wilderness. Should there be multi-use lands for recreational use and commercial harvesting? What should be the balance between government-owned and privately-owned forests? Should clear cutting of forest lands be allowed?

These kinds of decisions, however, should be made from a knowledge base rather than from an emotional one. To take an informed stand on an issue, you should understand the scientific and technological principles involved. Issues of proper forest use must balance environmental and economic issues.

A background in both science and technology can help you to arrive at decisions based on knowledge. For example, will young trees, of the predominant species, grow in the shade of older trees? (This is a scientific issue.) Can mature trees be successfully harvested without undue damage to surrounding trees? (This is a technological issue.)

Underlying all of these studies is the fourth area of human knowledge. Called **descriptive knowledge**, it includes language and mathematics. These are the "tools" you use to describe what you see and know. Descriptive knowledge is the basis for communication. As you read this book, topics are described through words, drawings, and formulas. Descriptive knowledge allows you to study and understand aspects of science, technology, and the humanities.

TECHNOLOGY

Whether you realize it or not, technology has an impact on your life every day. Technology plays a part in almost all aspects of your life, from the food you eat and the clothes you wear, to the home in which you live and the book you are now reading.

What is technology? There seem to be as many definitions for technology as there are people trying to define it. However, some basic elements are included in most of these definitions. These elements, as shown in Fig. 1-3, suggest that:

- Technology is human knowledge.
- Technology is concerned with tools, systems, and procedures.
- Technology is used to create physical artifacts (structures and products).
- Technology attempts to modify (change) and control the natural and human-made environment.

Technology is the way people extend their potential. It magnifies human ability. Through technological systems, we can build better structures. Tools allow us to shape and form materials into products more efficiently. Other technological systems extend

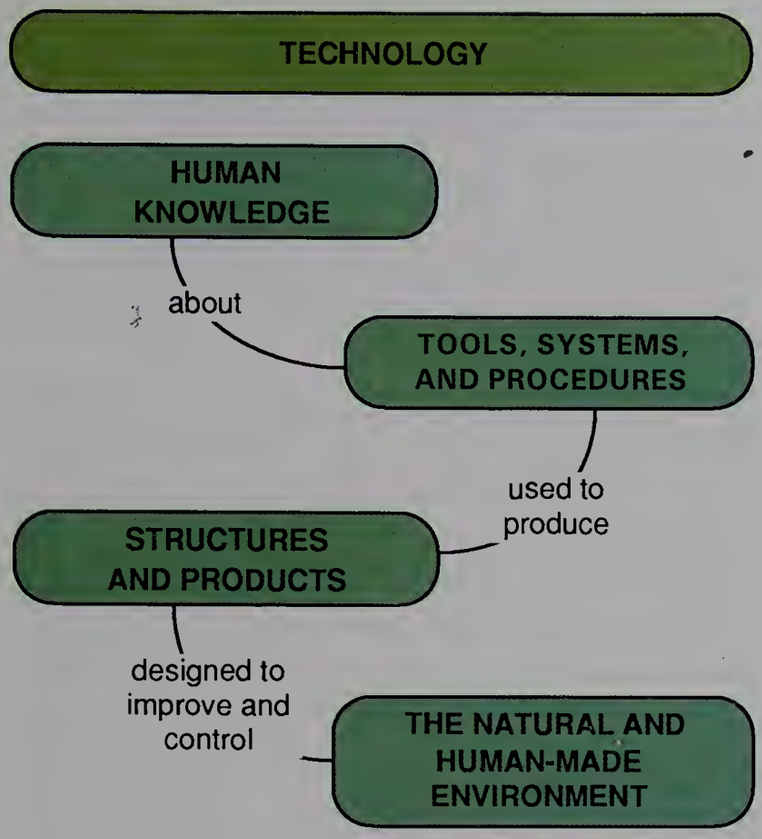


Fig. 1-3. These are common elements in the definition of technology.

our ability to communicate. Devices can convey our ideas and knowledge over long distances. Other devices can store information and retrieve it later. Through technology, we have vehicles that can move people and cargo effectively. Communication and transportation technology seem to have "shrunk" the world. We can travel long distances in a relatively short time. Information comes to us from all parts of the globe almost instantly.

Often, technology is thought to be complex tools and machines such as computers, robots, and fiber optic communication devices. In fact, they are often called *"hi-tech"* (high technology) devices. However, these are just the hardware. They are the tools of technology. Technology encompasses (takes in) the complete system. Technology is the knowledge of computer design, material processing, information communication and storage, energy utilization, tools, and a great deal more. It includes knowledge about designing, using, and maintaining products and structures (buildings, roads, dams, etc.). Technology also includes knowledge about appropriate actions. It considers the positive and negative impacts of human-made systems and products. A simple computer-controlled machine will use all of this knowledge and more.

Since technology is always changing, hi-tech is a relative term. This is because a level of technology is related to a point in history. Look at the photos in Fig. 1-4. Each of these represents high technological advancement at a point in agricultural history. The wooden plow replaced the digging stick and represented a major technological advancement. The wooden plow was considered to be a hi-tech device in its day. Likewise, the other three plows in Fig. 1-4 were also considered to be hi-tech devices, but only at the time they were developed.

The term, hi-tech, is also related to the development of a specific country or region. Not all countries of the world are at the same stage of technological advancement. That is why each of the plows shown may well be a hi-tech device today, depending upon where in the world you find it.

Another example of technological change can be seen in photography. Earlier photographs were only available in black and white. Now color photographs are quite common, even though they were considered to be hi-tech in the past.

It is probably better to think of technological advancements as **evolving technologies**. They will be hi-tech for a period of time but will then be replaced with an even more hi-tech device. Many people today can remember when television, the computer, passenger aircraft, plastics, radar, and the dial telephone were first developed. Each of these devices was a major technological advancement. Can you think of new evolving technological devices that have been developed in your own lifetime?

ELEMENTS OF TECHNOLOGICAL SYSTEMS

The world is made up of all types of systems. A system is an organization of people or a group of parts that operate together to achieve a single purpose or goal. Nearly everything we see is part of a system. This means that there are parts and these parts are interrelated. An example would be the solar system. The parts include the sun, the planets, and the moons of the planets. Other natural systems can be found in the human body, such as the circulatory system, digestive system, nervous system, etc.

Technological systems contain five essential elements. These elements, as shown in Fig. 1-5, include:

1. Inputs.
2. Processes.
3. Outputs.
4. Feedback.
5. Goals.

These elements are interrelated. They must all be present and work with the other elements if the



Fig. 1-4. These are examples of the evolving technology of the plow. (Deere and Co.)

system is to operate properly. A bicycle is a simple example of a system. The *input* is energy (the rider pressing on the pedals). The movement of the pedals and chain to turn the back wheel is the *process*. The *output* is the movement of the bicycle. The rate of speed can be measured and used as *feedback*. All of the parts of this system have a *goal*–to move the rider along the path or street.

INPUTS

All systems start with inputs. **Inputs** are items put into a system to receive outputs and achieve goals. For instance, your digestive system must have food and water (inputs) before it can work. Likewise, technological systems must have inputs. The basic inputs may be grouped into six categories. These, as shown in Fig. 1-6, are:

1. People.
2. Natural resources.
3. Capital (tools and machines).
4. Finance (money).
5. Knowledge (information).
6. Energy.

All six inputs must be present, in their proper balance, for the system to operate effectively. For

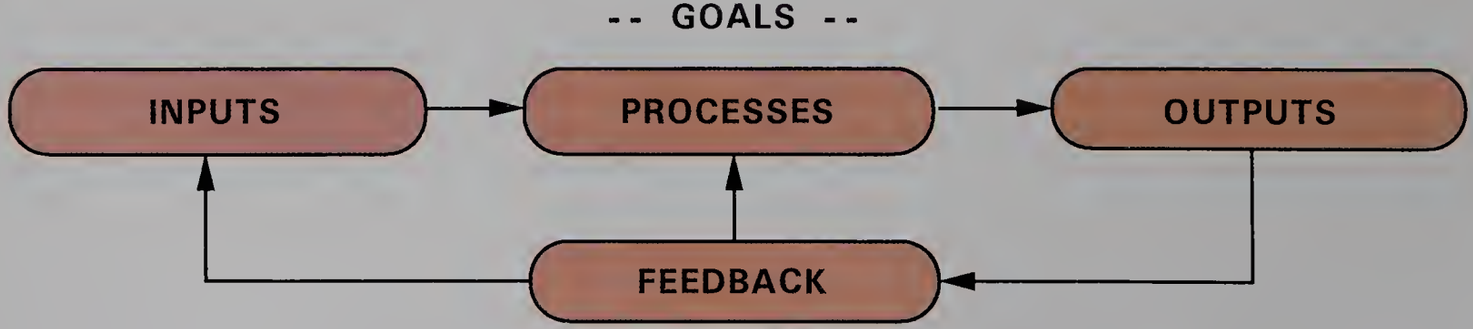


Fig. 1-5. These are the elements of technological systems.

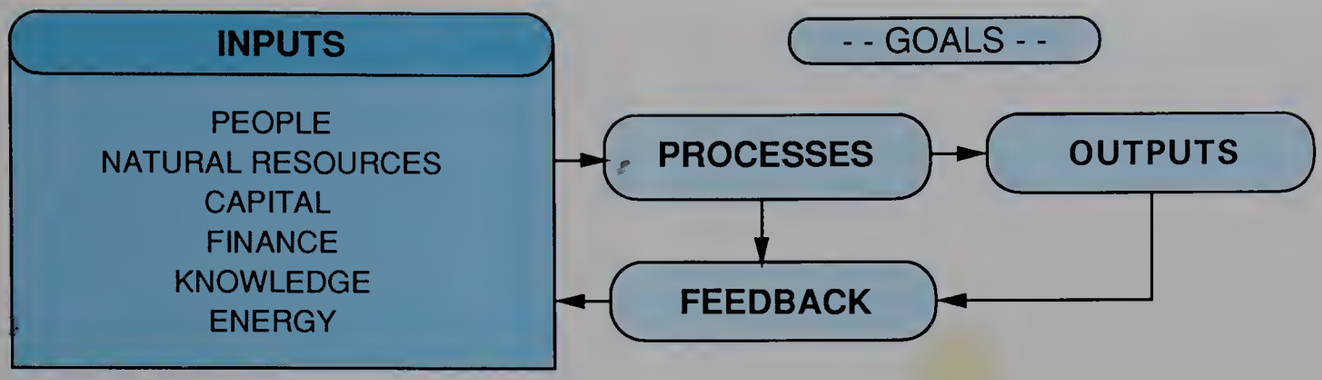


Fig. 1-6. These are inputs required by technological systems.

instance, suppose your class is organized into a system to produce a wooden toy. You have enough students to do the work. You have wood to make into parts. You have power tools to shape the wood. You have money to pay for materials and workers. You have plans (knowledge) for the toy. You have electrical power to run the tools as well as human energy. When all of these inputs are balanced, the wooden toy can be produced and the system should operate effectively.

People

Technological systems are developed and operated by people for their benefit. Without people, technology would not exist, nor would there be a reason for it. Technology needs many different types of people, Fig. 1-7. There is a need for people with mechanical skills to operate the tools and machines. Engineering, design, and creative skills are needed to design products. Interpersonal skills are needed to manage the human aspects. Logical or critical thinking is needed to schedule activities and to solve problems.

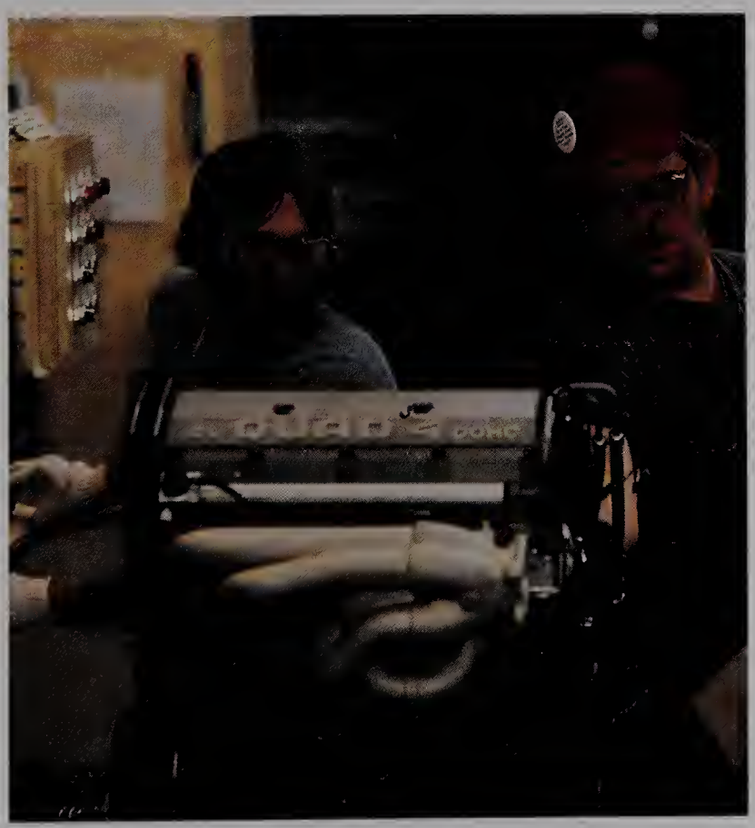


Fig. 1-7. People, with their skills and knowledge, are the foundation for technological systems. (General Motors Corp.)

Natural Resources

All technological systems use materials. These materials may be gases, liquids, or solids. They may be used to support the operation of the system or become part of the system output. Gases may be used to weld materials together. Liquids may lubricate machines. Solids may provide the structure for houses or aircraft.

Many technological systems change the form of materials, as shown in Fig. 1-8. They change iron ore, coke and limestone into pig iron. The pig iron is converted into steel. The steel may be rolled into sheets that can be used for refrigerators, automobiles, and filing cabinets. At each step, the material is more useful to people. Its value has been increased.

Capital

All technological systems use tools and machines. These are **capital**. See Fig. 1-9. This is what makes them "technological." You and your friend may stand in the hall and talk. You use language to communicate. However, you are not part of a technological system. However, if you talk to your friend over the telephone, technology is at work. A technological system has helped you communicate over a distance. The telephone receiver captured your voice. It changed this language-based sound into pulses of electricity, light, or microwave energy. It caused the pulses to move along a guideway. The path may have been a copper wire, fiber optic cable, or a microwave beam. At the other end, the pulses were changed back to sound. Your friend heard you talking. All of this was possible through the use of machines.

Finance

The old saying, "Money makes the world go around," may not be true. However, it does take money to make technological systems function. It costs money to design, build, and operate these systems. People must be paid for their labor. Materials and machines must be purchased. Owners expect a return on their investments. Taxes must be paid. Finance affects all aspects of a technological system.

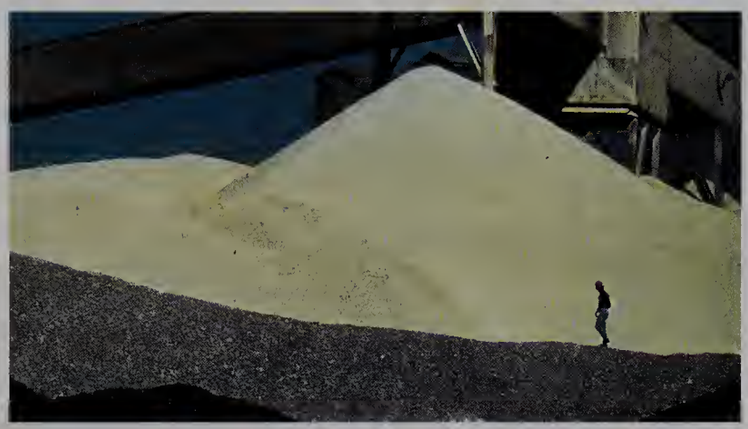






Fig. 1-8. Technological systems may change the form of materials. (American Iron and Steel Institute)

Knowledge

All technological systems are based on knowledge. To design and operate technological systems, we must have the knowledge to know how to build products, construct structures, communicate information, and transport goods and people. This knowledge is related to the desired outcome of the system.

Technological systems must also be managed. Goals must be set. Tasks must be set and completed. Outcomes must be evaluated. These actions require managerial knowledge. Managers must know how to combine resources so that they produce efficiently.

Knowledge can come from many different sources. It may be part of what workers bring to the job. It may also be in records, books, magazines, reports, films, tapes, or computer memories.

Energy

Energy is needed to do work. Humans use technological systems to extend their abilities beyond their personal strengths. See Fig. 1-10. Total technological systems use many types of energy. Most of the energy comes from burning fossil fuel (petroleum products and coal), falling water (hydroelectric power), and nuclear reactions. Additional energy comes from the wind, the sun (solar energy), chemical action (batteries, fuel cells), and geothermal sources (underground hot water). In some countries, burning wood is a primary source of energy.

PROCESSES

The second component in a technological system is the process. It is the part that actually does the work

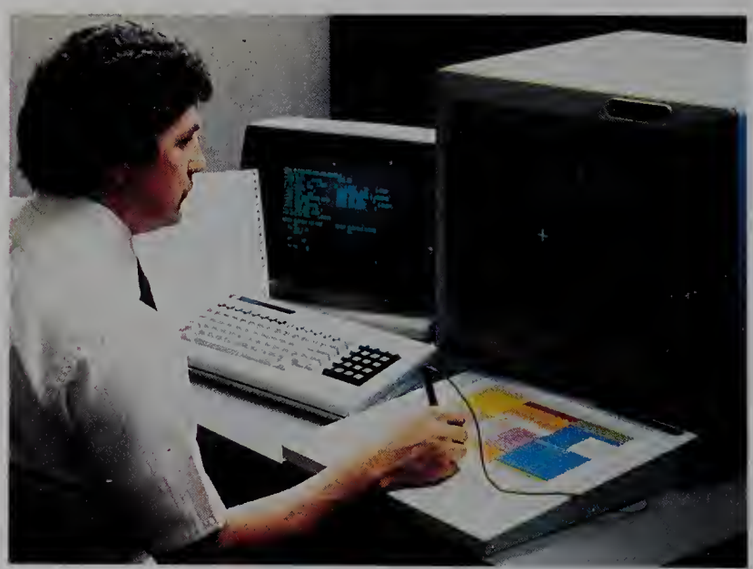


Fig. 1-9. This worker is using a machine to help make drawings. (AMP Inc.)





Fig. 1-10. Early technological systems used animal power. Now, technological systems use complex, powerful machines. (American Petroleum Institute, American Iron and Steel Institute)

of the system. There are two major types of processes. They are transformation and management. See Fig. 1-11.

Transformation processes deal directly with the inputs. Transformation processes use resources to create desired outputs. Each of the major technological systems has specific resources in which they transform resources into outputs. Communication technology uses resources to transform information into media messages. Manufacturing technology uses resources to transform materials into products. Construction technology uses resources to transform materials and manufactured products into structures. Transportation uses resources to transform energy into power to move people and cargo.

Management processes are used to insure the effective use of resources. It includes all the actions that insure that transformation acts are efficient and appropriate. Its goals are to see that transformation processes use resources effectively to produce quality outputs. For instance, products and structures must be well-made and function properly. Information must be accurate and easy to receive. People must be transported safely and in comfort. Goods must move quickly with the minimum of damage.

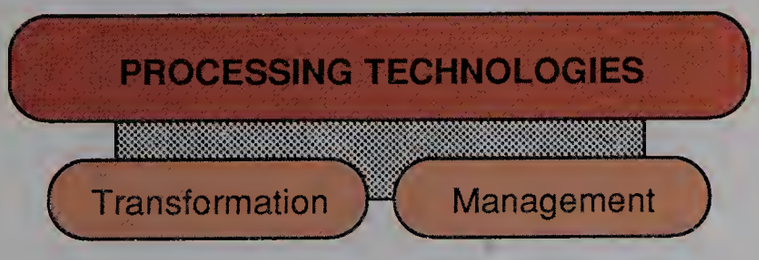


Fig. 1-11. These are types of technological processes.

OUTPUTS

Technological systems are designed to meet human needs and wants. They produce the **outputs** people want. These desired outputs may be manufactured products or constructed structures. They may be media messages that deliver information and ideas. These are the *desired* outputs of the system.

Most technological systems have other outputs. Scrap is produced as products are manufactured. Pollution is produced as the system operates. These are examples of *undesired* outputs. Noise, fumes, and liquid chemicals are given off by many technological systems. These outputs are often unavoidable. Carbon monoxide is a product of burning fuels. It cannot be avoided, but must be controlled. If you cut circles out of sheets of plywood, scrap will be produced. Again, it cannot be eliminated, but it can be held to a minimum. Aircraft engines make noise. It cannot be avoided, but it can be reduced.

The designers of technological systems face a common challenge. This is to produce the maximum amount of desired output with the minimum amount of undesired output. This will use resources wisely and minimize the damage to the environment.

FEEDBACK

Systems can use their own information to control themselves. This process is called **feedback**. The output is often measured. If it is not what is expected, corrective action usually results. For instance, consider a thermostat on a furnace. When there is enough warmth in the room, the thermostat sends a

signal that shuts off the furnace so that no more heat is produced.

Many modern manufacturing machines use a feedback system called *adaptive control*. For instance, consider a drill. The drill is being fed into the work. This places force on the motor and causes it to slow down. As the drill slows down, the feedback system senses the reduction in speed. It commands the feed system to reduce the feed rate for the drill. The slower feed rate reduces the force on the motor. It then regains its proper operating speed.

GOALS

Technological systems are directed and controlled by two types of goals. These types are system goals and societal goals.

The system is established to meet human needs or wants. These are the **system goals**.

Society has general goals that meet broader objectives. Society wants:

- People employed in challenging jobs.
- People to have a high standard of living.
- Our country to remain economically secure.
- To retain a technological lead in key activities.
- Our country to be strong and respected.

All of these goals are **societal goals**. They address the needs and wants of people as a larger group.

Technological systems must be adjusted to meet a balance of system and societal goals. For example, it is unacceptable to us to have workerless manufacturing. Products would be cheaper, but the resulting unemployment would cause many people extreme hardship.

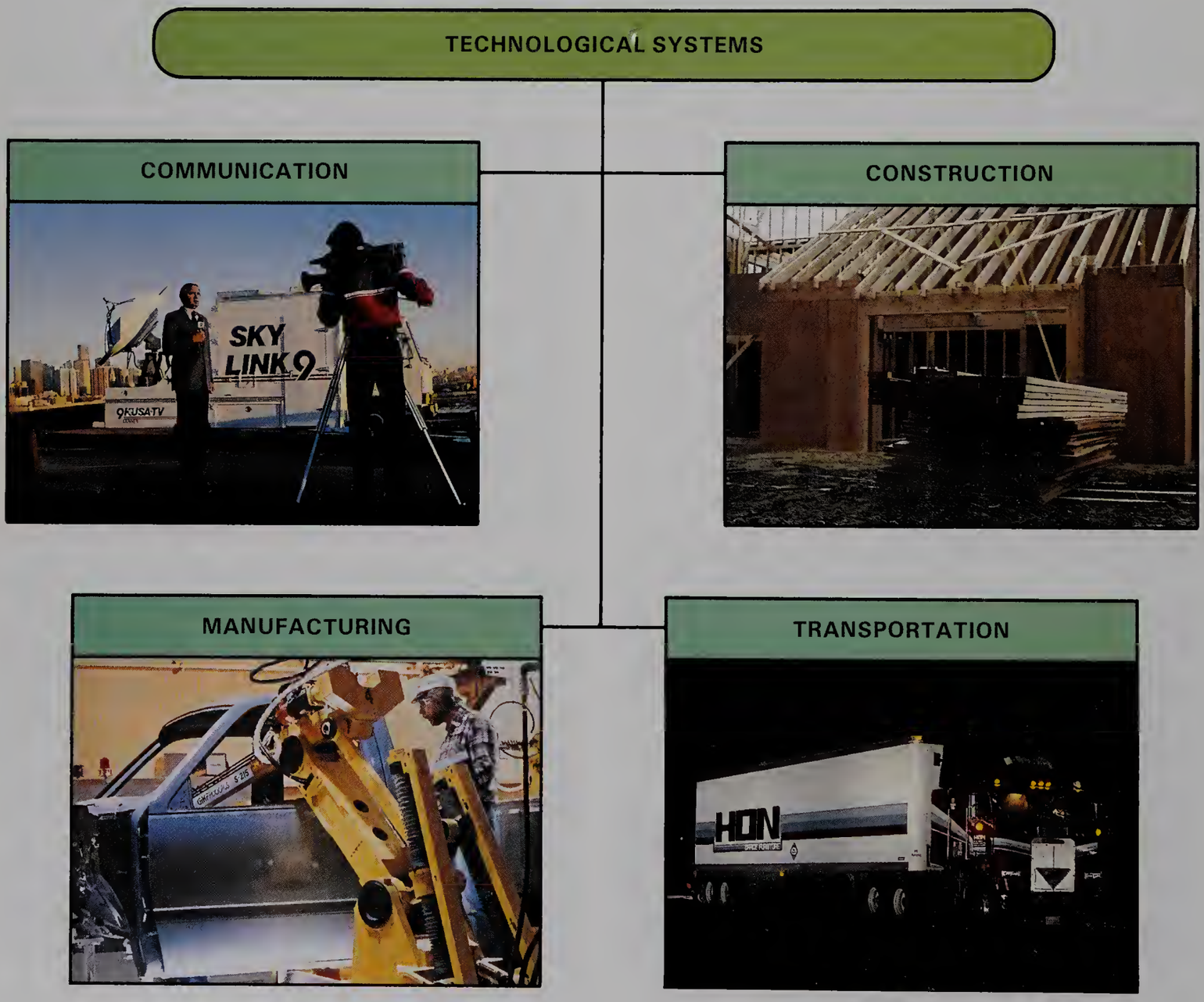


Fig. 1-12. These are the four major types of technological systems.

TYPES OF TECHNOLOGICAL SYSTEMS

There are many types of technological systems, as shown in Fig. 1-12. Each is designed to make lives better. They extend our potential. These systems may be private or industrial. **Private technological systems** are designed to meet an individual person's needs. For instance, you may use a personal technological system to build a picnic table in your garage. However, most technological systems are **industrial systems**. They are organized systems that transform resources into outputs for large numbers of people.

Both types of technological systems share common elements. They use tools and machines to meet their goals. They transform resources into desired outputs. They may also produce undesired outputs.

Technological systems may be divided into at least four major groups:

- **Communication technology:** This includes systems that communicate information and ideas using technical means (equipment). The product is often a media message designed to reach a mass audience.
- **Construction technology:** This includes systems that construct residential, commercial, and industrial buildings and civil structures (roads, pipelines, bridges, dams, etc.). The structures are produced on the site where they are to be used.
- **Manufacturing technology:** This includes systems that transform materials into products in a central location (factory). The products are then transported through a distribution system to the ultimate consumer.
- **Transportation technology:** This includes systems designed to move people and goods from one location to another. The systems include a vehicle and support systems (terminals, roadways, etc.).

Additionally, there are technological systems used to obtain material resources. **Extractive technology** (mining, drilling, harvesting) recovers resources from the earth and seas. **Biotechnology** is used to grow genetic resources (fish, animals, plants) and uses living organisms to reach specific goals (enzymes to clean up oil spills, etc.).

This text will address manufacturing technology as a system. It will give you insight into how manufacturing is used to efficiently produce the products that each of us use daily.

SUMMARY

Technology is everywhere. It impacts every person. Technology is different from science. Science explains the natural world, while technology explains the human-made world. Technology is the use of tools, materials, and systems to produce products and structures that modify and control the world. It is a knowledge of efficient and appropriate action. All technological systems evolve. They are being improved to better meet human needs and wants.

Technology is a system with inputs, processes, and outputs. It often uses feedback loops to maintain proper operating conditions. The design and operation of technological systems are affected by individual and societal goals.

Technological systems may be small, personal ones or large, industrial ones. They also may be grouped into types. The major types are communication construction, manufacturing and transportation. Additionally, extractive and biotechnological systems provide the material resources for the four basic systems.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

biotechnology
capital
communication technology
construction technology
descriptive knowledge
energy
evolving technologies
extractive technology
feedback
humanities
industrial system
inputs
management processes
manufacturing technology
outputs
private technological system
science
societal goals
system goals
technological systems
technology
transformation processes
transportation technology

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the four major groups of knowledge.

2. True or False? A background in both science and technology can help you to arrive at decisions based on knowledge.
3. True or False? Technology is always changing.
4. List the five essential elements of a technological system.
5. Is capital an input or an output?
6. _____ processes use resources to create desired outputs.
7. _____ processes are used to increase the effective use of resources.
8. Noise, fumes, and liquid chemicals given off by technological systems are:
   a. Undesirable outputs.
   b. Desirable outputs.
   c. Often unavoidable.
   d. Both a and c.
9. Technological systems that transform resources into outputs for large numbers of people are _____ (private, industrial) systems.
10. Technological systems may be divided into at least four major groups. What are they?

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Develop a poster, transparency, or bulletin board that would define technology for someone who is unfamiliar with the word.
2. Distinguish between science and technology. Then give four examples of how each affects your everyday life.
3. Use a managed manufacturing system to produce a product. The tic-tac-toe game shown in Fig. 1-A is an example of a simple line production project. Follow the steps below to select and produce your product.
   a. Decide what the class will manufacture. Check catalogs, magazines, and any other literature supplied by your instructor for ideas. Visit local stores for suggestions.
   b. Following a planning session with your instructor, select an appropriate sequence of manufacturing operations.
   c. Determine the tools and materials needed to successfully manufacture the product.
   d. Organize the manufacturing team for the production run. Is every task or job covered?
   e. Review each worker's production line assignment. Are the tools and materials on hand to start the production run?
   f. Following all safety rules, make the production run.

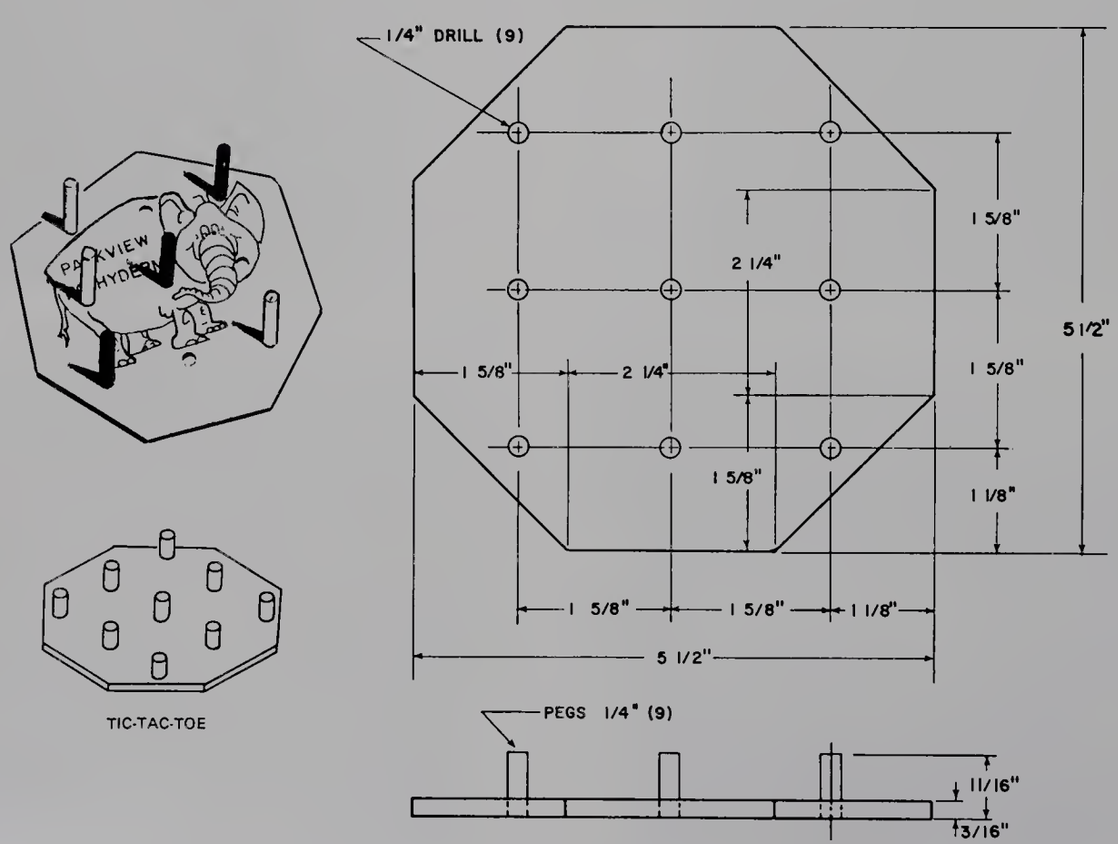


Fig. 1-A. Several manufacturing operations are involved in producing this line production product. These plans give details on how to manufacture it.

2

CHAPTER

MANUFACTURING SYSTEM COMPONENTS

After studying this chapter, you will be able to:
- *Describe how manufacturing has evolved.*
- *List the major components of a manufacturing system.*
- *Identify manufacturing inputs.*
- *Describe manufacturing processes.*
- *Identify manufacturing outputs.*

Look around you. Manufactured products are everywhere. The furniture, lighting, fixtures, windows, doors, floor coverings, books, and pencils were all manufactured. Even the clothing you are wearing was manufactured. Outside, there are power poles, street lights, fences, and automobiles, all of which were manufactured. Each product was carefully designed, produced, and marketed. They are the desired outputs of manufacturing systems.

THE EVOLUTION OF MANUFACTURING

Manufacturing is as old as human life itself. People have always made things from materials found on earth. Early manufacturing was done for personal use. People made weapons, clothing, and cookware for survival and to make life easier. The processes they used were the manufacturing technology of their time. It represented activity in making and using products to extend human ability. With these products, people could hunt better, stay warmer, and cook food more easily.

Making products for personal use has been called *usufacturing* or "making for use." This earliest manufacturing activity used simple technologies. Crude tools and natural materials were the foundation of this stage of development. Societies based on this type of production were in their handicraft era or age.

Later in history, people started to make products for other people. Individuals developed skills in using certain materials and tools, Fig. 2-1. They



Fig. 2-1. People in early manufacturing used simple tools and materials.

would concentrate on making a special type of product. This is how some people became carpenters, while others became shoemakers, or weavers, etc. They would trade (barter) their products for things they needed. For instance, a carpenter might trade a stool for a pair of shoes.

This was the beginning of *manufacturing* or "making products in a mechanical manner." As specialization grew, manufacturing became concentrated into special buildings called **factories.** Cities grew, and many people left the farms for jobs in the factories. Employees were divided into workers and managers. During this period, manufacturing used machines to produce a large quantity of a specific product. The emphasis was on material processing–people using machines to make products from materials. This resulted in an **industrialized society**.

Today, we are moving into an age where products are first made in the mind. This has been called *mentafacturing* or "making in the human mind." This ability has been made possible with the development of the computer. Emphasis has moved from processing materials to processing information. Computer-driven machines, like the one shown in Fig. 2-2, can prepare drawings, monitor machine operations, inspect products, and maintain production records.



Fig. 2-2. This designer is using a CAD (computer-aided design) system to design and test automotive bodies. (Chrysler Corp.)

With these developments, society has moved into the information age. Examples of information age products include the Boeing 757 and 767 passenger jets, Fig. 2-3. These aircraft were "manufactured" and "flown" on a computer before the actual aircraft were built. With computers, the human mind can conceive, design, build, and test products before the human hand will actually operate machines to process materials.



Fig. 2-3. The Boeing 767 is a product of the information age. (The Boeing Co.)

All these manufacturing methods can be viewed as complete systems. In Chapter 1, you learned that a system has several components. These include inputs, processes, outputs, feedback, and goals.

For example, communication systems transform information (input) into media messages (output). These messages may be communicated using the printed media, photographs, or electronic means (processes). The messages are designed to inform and persuade people (goal). It is hoped that we will know, move, or act differently because of the communication process.

Transportation is another example. Transportation transforms energy (input) into power to propel vehicles (process). These vehicles move people and cargo safely and efficiently (output). The person or the item will be in a new, desired location (goal). The transportation system brings us products and allows us to travel anywhere in the world.

Do you see that every technology has the same components? Now, let's look at these system components as they specifically apply to manufacturing.

MANUFACTURING AS A SYSTEM

The manufacturing system provides you with nearly all the physical products you use daily. The car in which you ride, the television you watch, the food you eat, and the clothes you wear are all manufactured. Products such as these can make life better. This is the reason humans developed manufacturing in the first place. To understand manufacturing, you should view the three major components of the system. These are inputs, processes, and outputs.

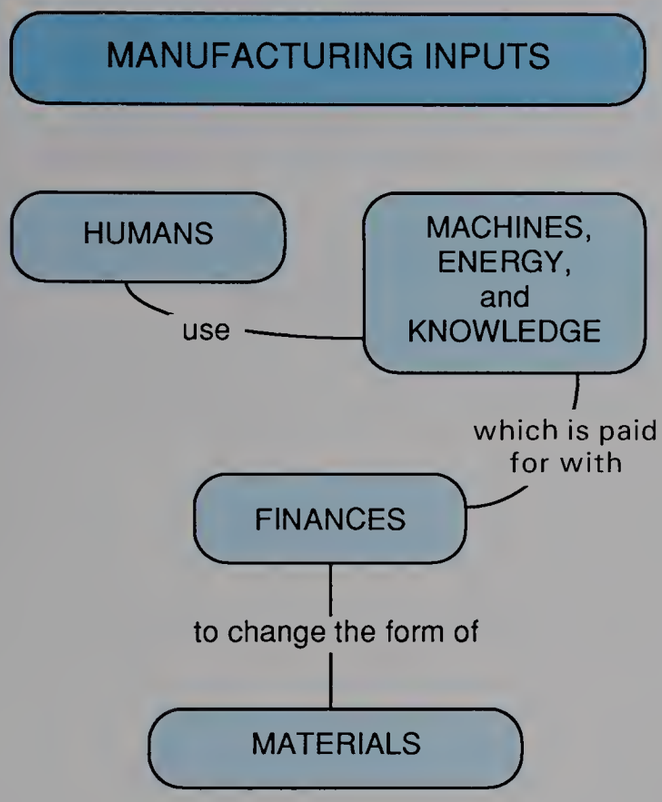


Fig. 2-4. Manufacturing uses resources to change the form of materials.

MANUFACTURING INPUTS

All systems have the same inputs. They use human labor, information, capital (machines and equipment), energy, materials, and finances. However, each system has an input that it is designed to transform (change).

Manufacturing transforms materials into products, Fig. 2-4. It changes the form of a material to make it more useful. This action is called **form utility**. For instance, you probably find a plastic CD recording worth more than a pile of plastic pellets. Likewise, most people feel a wood chair is worth more than a pile of boards. The new form has more utility (usefulness) and, therefore, we place a higher value (worth) on it, Fig. 2-5.

MANUFACTURING PROCESSES

New material forms don't just happen. They are the direct effort of many people working together. They are part of a manufacturing team that applies two basic process technologies. These technologies are used and interact to complete the transformation task, Fig. 2-6. The two manufacturing process technologies are transformation and managerial.

The appropriate use of tools, machines, and systems to convert materials into products is called **transformation technology**. This technology is often called **material processing technology**.

The appropriate use of systems and procedures to insure that transformation actions are efficient and appropriate is called **managerial technology**. This technology is used by both workers and managers.

Manufacturing technologies are the focus of this book. Sections II and III will explain manufacturing



Fig. 2-5. Which form of the material shown above do you think has the most value or worth to the consumer–the logs on the left or the toys on the right?

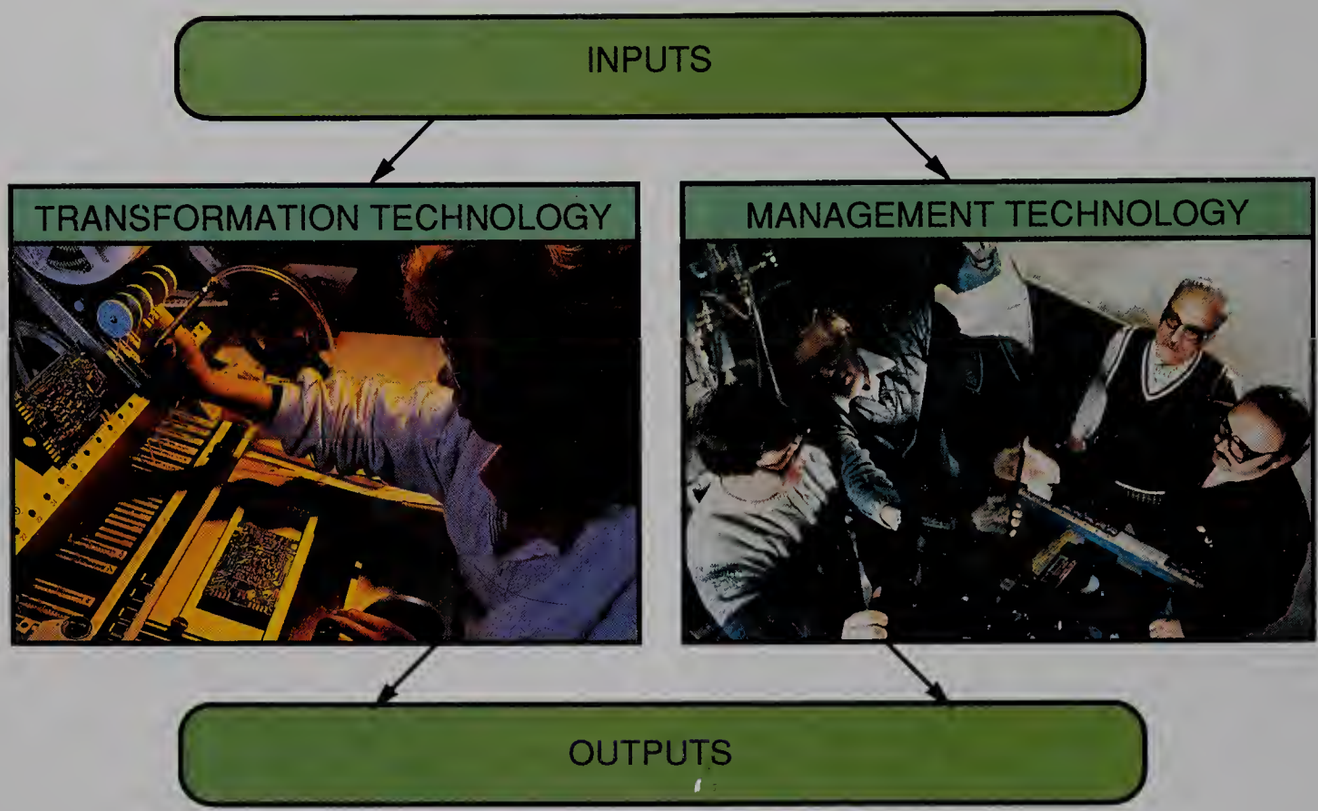


Fig. 2-6. These are types of processes in the manufacturing system. The worker on the left assembles a product using a *transformation* action while, on the right, the workers and managers participate in making a *managerial* decision. (Parker Hannifin Corp., Greensburg Windshield)

materials and processes used in transformation technology. Sections IV and V will present management and the managed enterprise. However, before the technologies are explored in depth, let's look at them in general to see how they interrelate.

Transformation technology

Transformation technology (material processing) creates form utility. It is people using machines efficiently and appropriately. Material transformation generally takes place in several steps. The steps are shown in Fig. 2-7.

All materials can be traced to a natural resource. They all are some form of a material found on earth. Most plastics come from natural gas and petroleum. Glass is often made from silica sand and soda ash. Steel is a combination of iron ore, carbon, and other elements. Aluminum is found in bauxite deposits.

The first step in the transformation process involves obtaining the natural resources. This may

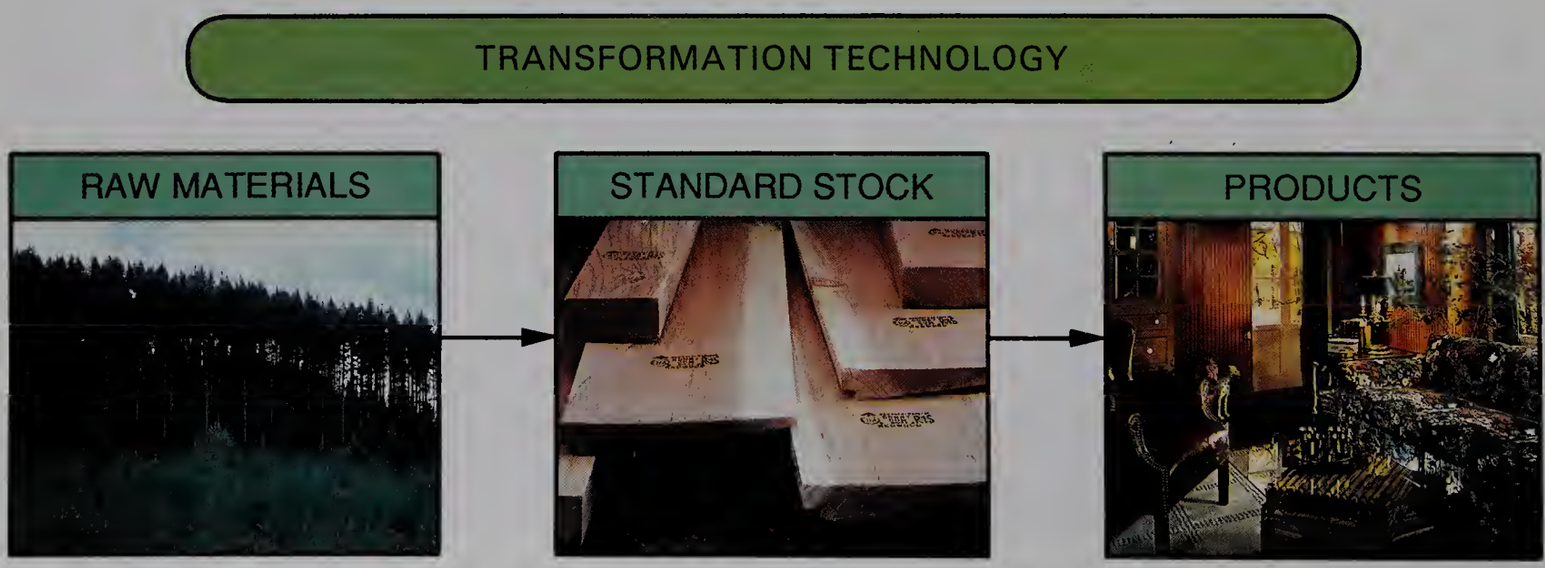


Fig. 2-7. These are examples of stages in material transformation. (Georgia-Pacific Corp.)

involve a search for deposits of ores or petroleum. It may require planting, growing, and harvesting trees or other crops. It may also include obtaining materials from the sea. These natural resources are the **raw materials** for the manufacturing process.

Next, natural resources are converted into a usable material. Trees may be transformed into lumber, plywood, particleboard, hardboard, or paper. Petroleum may become a fuel, lubricant, or plastic. Metallic ores may be reduced to copper, aluminum, tin, lead, or iron. These activities are considered to be **primary processing**. This first step in transforming materials into products is often performed by basic industries such as steel mills, copper smelters, lumber mills, and petroleum refineries. They provide the basic resources from which other products are made.

Generally, the output is produced in standard sizes. Lumber may be 1 x 12s or 2 x 4s. Plywood, particleboard, and hardboard are made in 4′ x 8′ sheets. Metal may be produced in standard-sized sheets, bars, or rods. Plastics with specific chemical composition are available. These materials are called **standard stock** or **industrial materials**.

However, standard stock has little value to most of us. What would you do with a truckload of plywood? It only becomes valuable to you when it is made into something useful. This process is called **secondary processing**. These actions continue to change the form of materials. Lumber becomes furniture, and plastic becomes dinnerware. Clay becomes bathtubs, and steel becomes automobiles.

Secondary processing shapes and forms materials through casting, forming, and separating actions. Parts are conditioned to give them new properties. Finishes are applied to protect and beautify the product. Then parts are assembled in subassemblies and products.

The result of all these activities are products for us to use. Also, many people find exciting and challenging careers in designing, producing, and marketing the products of manufacturing systems.

Managerial technology

Human-made systems must be designed, built, and operated. Goals must be set and courses of action selected. Resources must be obtained and assigned to various activities. The operation of the system must be constantly monitored. Outputs must be evaluated. These actions involve management technology. They involve planning, organizing, actuating (directing), and controlling.

Managerial technology is all the actions that insure that resources are used efficiently to produce appropriate products. Manufacturing management involves five basic areas of activity. These are research and development, production, marketing, financial affairs, and industrial relations.

Products and manufacturing processes must be designed and specified. This is the task of **research and development**.

The specified product must then be built. A production system must be designed. Manufacturing processes must be selected. Machines and tools must be brought into play. Materials are processed into products. These responsibilities are completed by the **production** activity area.

The completed product must reach the customer. Its availability and features are presented by advertising. The product is sold to wholesalers and retailers. From them, the final customers buy those products that meet their needs. This movement of products from the manufacturer to customers is called **marketing**.

Research and development, production, and marketing are the three activities directly involved with the product. They design, produce, and distribute the outputs of the manufacturing system. However, other areas are needed. Finances are needed. **Financial affairs** raises money and maintains financial records. Human resources and attitudes must also be developed. **Industrial relations** deals with the human aspects of the system through personnel, labor, and public relations programs.

Without management, efficient production would not happen. Management is essential for all goal-oriented activities, whether they be in industry, sports, or your personal life.

MANUFACTURING OUTPUTS

Human-made systems are developed for a reason. The manufacturing system has been developed to produce the products we need and want, Fig. 2-8. These are the desired outputs of the system.

However, undesired outputs can also result. Factories may create pollution. Fumes can enter the air. Chemicals can mix with ground water. Also, noise can pollute quiet areas. Some pollution is unavoidable. The challenge is to control these undesirable products of the manufacturing system.

Most outputs of manufacturing systems have a useful life. After this time, the products are often discarded. However, with an increasing concern about pollution and resource depletion, manufactured products should be recycled after they serve their purpose. This allows the worn-out or obsolete

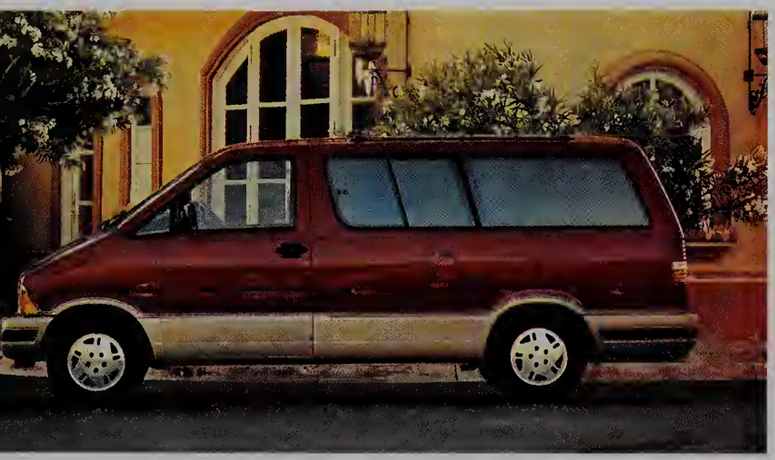




Fig. 2-8. New products, like these transportation vehicles, are designed to meet human needs and wants. (General Motors Corp. and United Airlines)

products to become a material input for a new manufacturing activity. Large scale recycling activities are already in place for aluminum, glass, and paper. Others will soon follow. If consumers and manufacturers begin recycling their scrap, waste, and obsolete products, the stress on the environment will be reduced. This will benefit everyone.

Another set of "products" of manufacturing systems are human outputs. Manufacturing creates jobs. Some of these are directly in the factory or in marketing the product. Others support the factory and its workers. Many stores and service businesses disappear when a factory leaves a town or goes out of business. Manufacturing systems also impact people and their lifestyles. Employment means income, physical and mental challenges, and a feeling of worth, Fig. 2-9.



Fig. 2-9. Working in the manufacturing system can be challenging and exciting. (AT&T Archives)

New manufacturing systems require people to receive additional education. Recently, a major corporation said that the worker in the future will constantly need to be in training just to stay ahead. Flexible people, who are willing to learn, can face a lifelong challenge in manufacturing. Those who cannot or will not adapt to new job requirements most likely will face unemployment. This "change and advance" or "stand still and lose out" attitude can be considered an output of the system.

SUMMARY

Manufacturing has evolved from producing products for personal use to complex systems that give us a wealth of goods. The manufacturing system changes materials into a more usable form. It moves raw materials into standard stock that is converted into products. Without manufacturing, fewer people would have meaningful jobs. Also, communities, states, and the nation would suffer economic distress.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

factories
financial affairs
form utility
industrial materials
industrial relations
industrialized society

managerial technology
marketing
material processing technology
primary processing
production
raw materials
research and development
secondary processing
standard stock
transformation technology

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Describe the difference between *usufacture*, *manufacture*, and *mentafacture* in terms of the types of work people do and the machines they use.
2. List the three major components of the manufacturing system.
3. Human labor, information, capital, energy, materials, and finances are examples of manufacturing _____.
4. What are the two manufacturing process technologies used by manufacturing systems?
5. True or False? Transformation technology creates form utility.
6. True or False? All materials can be traced to a natural resource.
7. List the five basic areas of activity involved in manufacturing management.
8. Products and pollution are examples of _____ of a manufacturing system.

APPLYING YOUR KNOWLEDGE

1. Develop a poster that shows the basic components of a manufacturing system.
   a. Get posterboard or suitable backing from your instructor.
   b. Select a type of manufacturing that appeals to you.
   c. Select a method of presenting your material. Do you wish to draw the parts? Perhaps you would prefer to clip art or photographs from old magazines or advertisements.
   d. Assemble your materials. You may wish to include marking pens for preparing the message.
2. Select a product in your technology education laboratory or from your home to study.
   a. Construct a chart with two columns.
   b. In the first column, list all the material inputs that you think were used to produce it. (Study the product carefully. Not all materials are immediately noticeable!)
   c. In the second column, list as many undesirable outputs as occur to you. These are outputs that may have been the result of the manufacturing system and its processes.
3. Refer to the manufacturing activity (Fig. 1-A) described in Chapter 1.
   a. Make a chart similar to the one in Fig. 2-A.
   b. List the material inputs for the manufacturing activity in Chapter 1.
   c. Next, list the transformation (changing the material) activities.
   d. Finally list all the outputs of the system.

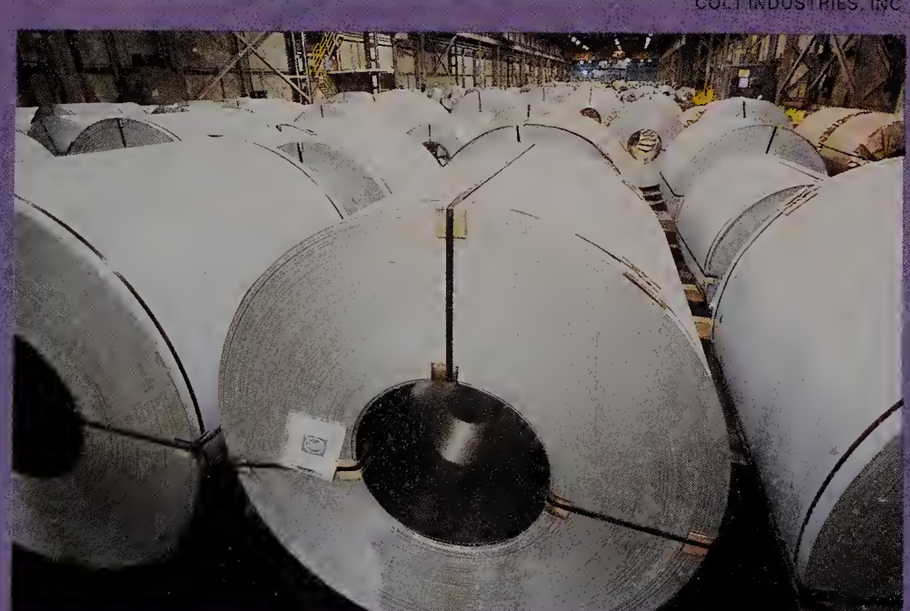
INPUTS	PROCESSES	OUTPUTS
Material:	**Transformation:**	**Desired:**
Human labor (types):		
Information:		
Capital (plant and equipment):	**Managerial:**	**Undesired:**
Energy (types):		
Finances (product cost):		

Fig. 2-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.



COLT INDUSTRIES, INC.

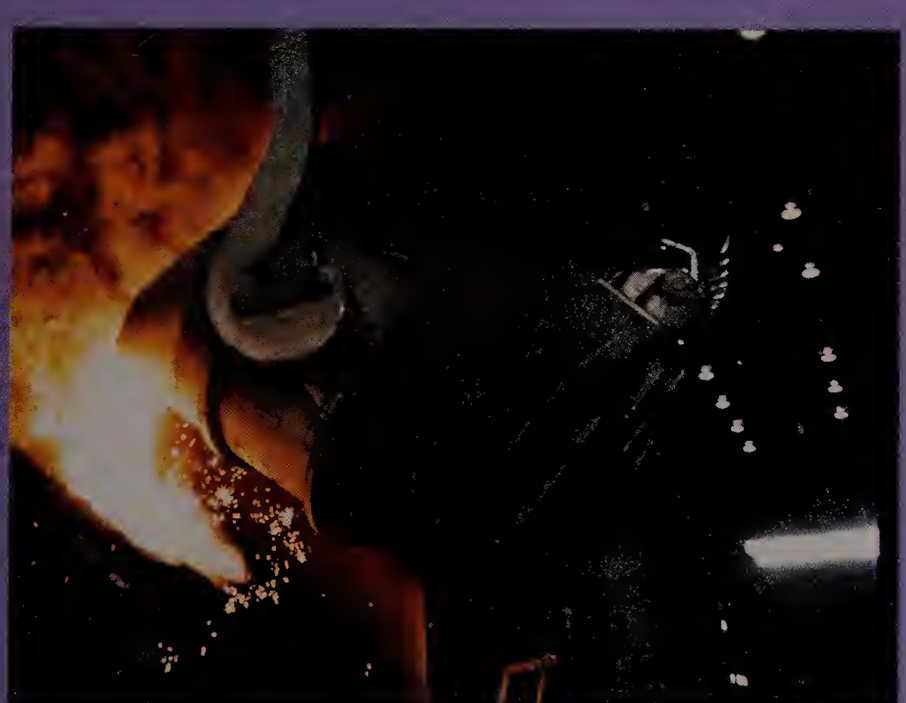


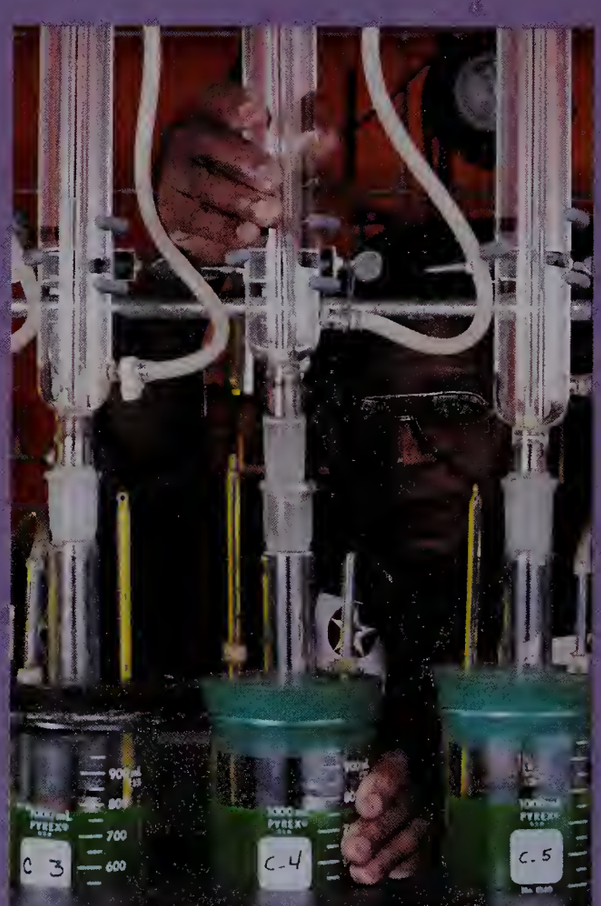


section 2

Manufacturing Materials

3. Materials and Manufacturing
4. Structure of Materials
5. Material Properties





TEXACO INC.



This automobile started out as industrial materials such as steel, glass, rubber, and plastic. (Ford Motor Co.)

3

CHAPTER

MATERIALS AND MANUFACTURING

After studying this chapter, you will be able to:

- *Describe the relationship between materials and manufacturing.*
- *Distinguish between organic and inorganic materials.*
- *List the three major types of materials.*
- *Identify and describe metallic, polymeric, and ceramic materials.*
- *Give examples of composite materials.*

We live in a world of materials, Fig. 3-1. Your home, your school, your bike, and the sidewalk on which you ride your bike are all made of materials. Everything on earth is made from one type of material or another.



Fig. 3-1. Consider the number of manufactured materials that were used to build and furnish this home. Materials were also used in manufacturing the tools and machines used in building the home. (Georgia-Pacific Corp.)

Throughout history, humans have developed methods of changing many of these materials. We change their shape, their size, or the way they are combined with one another. This process is called **manufacturing**, Fig. 3-2.

Materials are used to produce the products that make our lives easier, safer, and more enjoyable. Other materials are used to construct buildings and other structures produced by the construction industry. Still other materials are manufactured into vehicles that transport us over long distances. Finally, materials are needed for the equipment and media used to communicate information and ideas.

A few materials can be used as they are found on earth. People may use natural gravel and sand to construct a road. Berries may be eaten directly from plants and vines. Trees may be cut into firewood to heat our homes.

However, most materials require processing to be fully useful. Iron ore, coke (processed coal), and

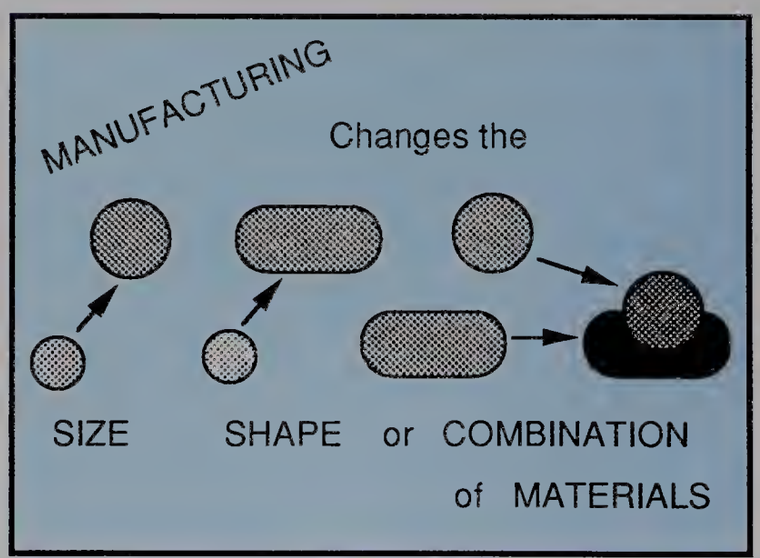


Fig. 3-2. Manufacturing changes the form of materials.

limestone can be converted into pig iron. Trees can be sawed into lumber, digested to produce paper, or flaked for particleboard. Bauxite is changed into alumina that is converted into aluminum. Other ores are smelted (refined) to extract copper, gold, silver, and many other metallic materials. Natural gas may be processed to produce plastics. Silica sand may be changed into glass.

MATERIALS USED IN MANUFACTURING

Materials come from two basic sources. They were either once living organisms (or part of living organisms) or they never had life. Materials that can be traced back to living things are called **organic materials**. Common examples of these materials are coal, petroleum, wood, and wool. **Inorganic materials** are the nonliving ores and earth elements. Copper, gold, aluminum, glass, cement, and rock are typical inorganic materials.

Organic and inorganic materials are found in three physical states: gases, liquids, and solids. Solid materials are often called **engineering materials**. These materials have a solid structure. They will hold their shapes without outside support. Gases and liquids are **nonengineering materials**. They must have a container if they are to be confined or held in a particular shape. Gases and liquids that have important industrial applications are fuels, lubricants, and water.

Engineering materials are used to give durable products their structure or framework. These materials, as shown in Fig. 3-3, can be divided into three basic categories:

- Metallic materials.
- Polymeric materials.
- Ceramic materials.

METALLIC MATERIALS

Metals are the most widely used group of engineering materials. Three-fourths of all natural elements are classified as metals. About one-half of these have some industrial application and value. These materials have desirable mechanical and physical properties, are readily available, and can be processed using a wide variety of techniques.

Most commercial metals are obtained from their **ores**. Ores are earth or rock from which metals can be commercially extracted. Metal-bearing rocks that cannot be refined economically are not called ores.

In rare cases, metals appear in veins of pure material. The legendary Mother Lode of Nevada contained such veins of silver. However, most metal is

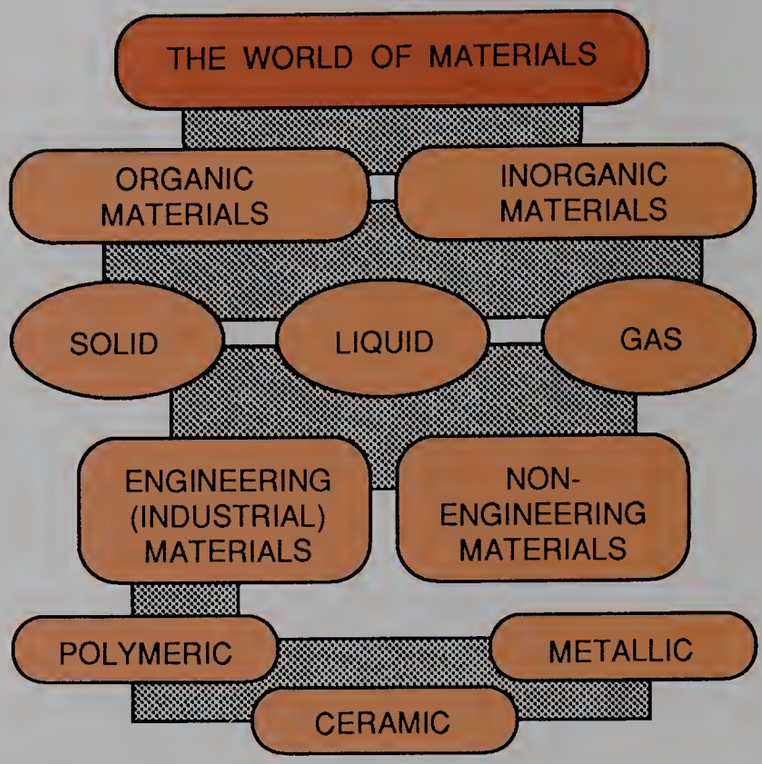


Fig. 3-3. A variety of materials is used in manufacturing.

extracted from its ore and concentrated. It is then shipped for final refining into useful industrial materials. During refining, the impurities are separated and removed in the form of slag, Fig. 3-4.

Metallic materials are inorganic, crystalline substances. See Fig. 3-5. Individual crystals are made up of unit cells. These cells, as will be discussed in Chapter 4, form three-dimensional, crystal lattice structures.

Pure metals have a wide range of physical and mechanical properties. However, they are seldom used in the pure state. Instead, they are generally combined with other metals or inorganic materials to produce an **alloy**. This new material can be engineered to have properties that better match specific needs. Metals are generally grouped into two major categories: ferrous and nonferrous metals.

Ferrous metals

Iron is the fundamental ingredient for all **ferrous metals**. These materials have a broad range of iron content. Carbon steel and cast iron are composed of over 90 percent iron. Specialty iron alloys (steels) can have nearly 50 percent alloying elements.

All ferrous metals (irons and steels) are classified as *iron-carbon alloys*. Carbon content in ferrous metals ranges from less than 1 percent in most steels to 4 percent of cast iron. Other alloying elements may exceed the percentage of carbon. However, carbon is the most important alloying element in determining the mechanical properties of ferrous metals.



Fig. 3-4. The worker on the left is tapping molten iron from a blast furnace. This class of materials is developed and engineered by chemists to meet specific needs. The view on the right shows molten slag (impurities) being removed from a ladle. (American Iron and Steel Institute, Harsco Corp.)

Iron is a very common commercial material. It has been used for many years. Iron appears in a free state only in meteorites. Common iron and steel materials start with iron ore. The first processing step produces pig iron in blast furnaces, Fig. 3-6. This pig iron can be changed into wrought iron that is hammered or rolled into shape. The other form of iron is called cast iron that has about 3 percent carbon. This material is used for many products including heavy machinery parts and automobile engine blocks. Pig iron, along with scrap steel, can also be the basic ingredient to produce new steel.

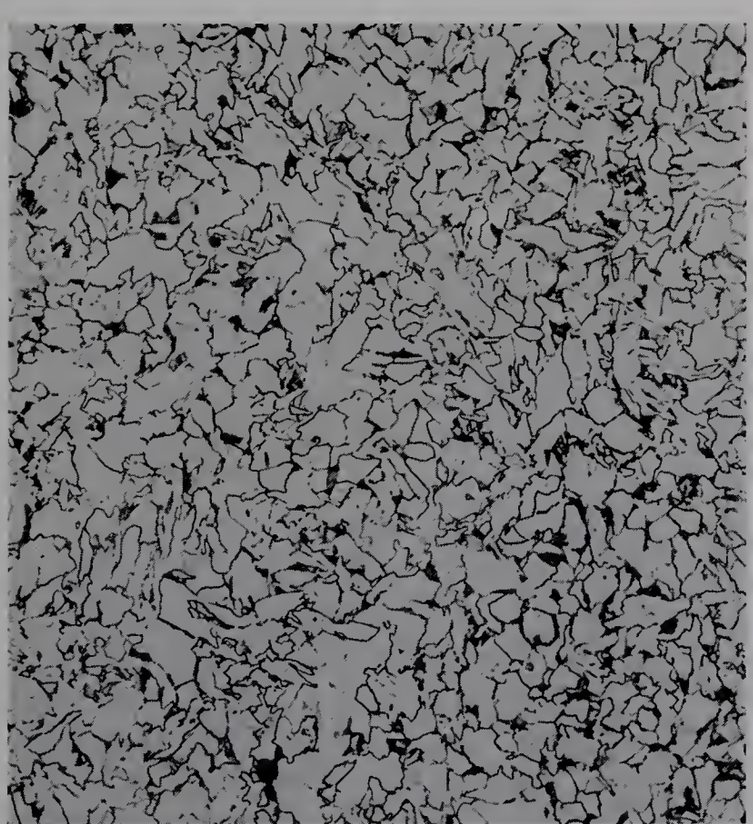


Fig. 3-5. This is a piece of mild steel that has been magnified 500 times. Note the crystalline structure.



Fig. 3-6. Blast furnaces, like this one, change iron ore, limestone, and coke into pig iron. (Inland Steel Co.)

Steels are grouped into two major types: Carbon steel and high alloy steel. Carbon is the major alloying element in all **carbon steels**. These materials can have up to 1.0 percent carbon but no more than 1.65 percent manganese, 0.60 percent silicon, and 0.60 percent copper. These steels are classified by a numbering system developed by the American Iron and Steel Institute (AISI). When the first number is 1 in this four-digit system, the steel is a carbon steel. The last two digits indicate the carbon content in points. A point is 1/100 of a percent. For example, AISI 1030 would mean that this carbon steel is 30 x .01 or .30 percent carbon.

Carbon steels, Fig. 3-7, are divided into three major classes:

- *Low carbon* or *mild steels*: These steels have a carbon content up to 0.30 percent carbon. These materials have low strength and high ductility They cannot be hardened by heat treating. Cold-working (rolling, drawing, etc.) increases the material's hardness and reduces its ductility.
- *Medium carbon steels*: These have a carbon content between 0.30 percent to 0.55 percent. These materials can be case hardened (a thin layer hardened) by heat treating. They are the most widely used steels for structural applications in the automotive, machinery, and agricultural equipment industries.
- *High carbon steels*: These are steels above 0.55 percent carbon. They are coarse materials that can be hardened by heat treatment. These materials are hard and resist wear. High carbon steels are used for products like springs, saw blades, piano wire, and drills.

High alloy steels contain significant alloying elements in addition to carbon. Two common high alloy steels are:

- *High-speed* or *tool steel*: This is a generic name applied to all steels that hold their sharpness under high temperatures. They generally use molybdenum and tungsten as heat resisting alloys. High-speed steels are widely used for cutting tools and forming dies.
- *Stainless steel*: This is a large family of iron-carbon-chromium alloys that have high corrosion resistance. This resistance is developed by a layer of chromium oxide that forms on the surface of the metal. Nickel is generally an important additional alloying element is stainless steels.

Nonferrous metals

Metals that do not have iron as their principal ingredient are called **nonferrous metals**. There are about 12 commercially important nonferrous metals. Some of these include aluminum, copper, lead, magnesium, titanium, chromium, silver, gold, and platinum.

The most commonly used nonferrous metal is *aluminum*. The material is the most widely distributed of all metals. It occurs in all common clays. Aluminum is separated from its ore in a two- step process. The ore, which is called bauxite, is chemically processed to form alumina or aluminum oxide. This material is electrolytically treated to produce pure aluminum from the oxide, Fig. 3-8. Aluminum is nonmagnetic, oxidizes readily at elevated temperatures, and is very malleable (able to be formed by hammering).

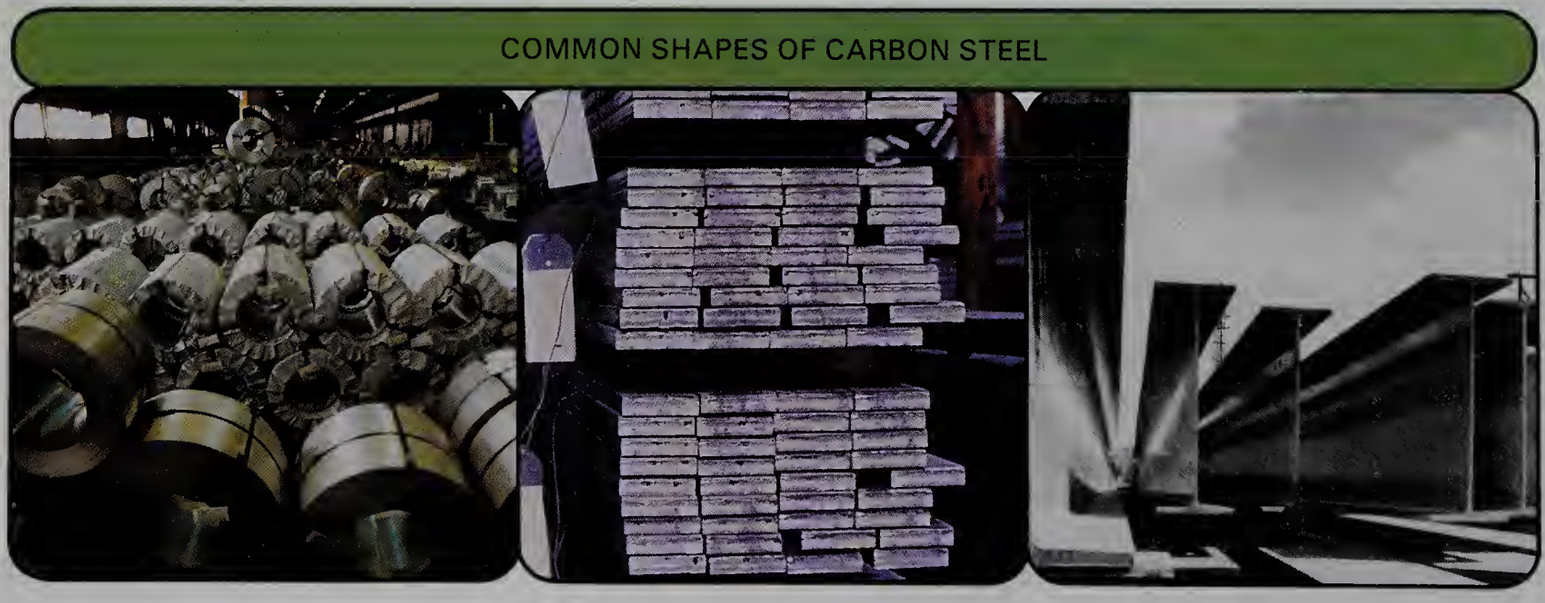


Fig. 3-7. Carbon steels are produced in sheets and coils(left); in bars, rods, and slabs (center); and in structural shapes (right). (United States Steel, American Iron and Steel Institute)

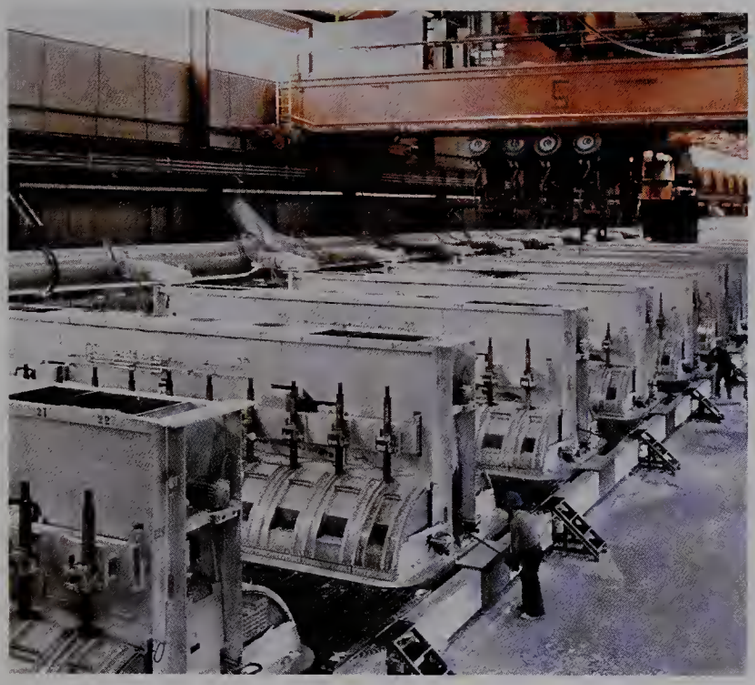


Fig. 3-8. This pot line is used to convert alumina into aluminum. (Alcan Aluminum Co.)

Aluminum is often produced in a commercially pure sheet or ingot. This material is 99.3 percent pure. Important aluminum alloys contain copper, zinc, tin, and/or lead.

Aluminum conducts heat well and is fairly chemically inert. For these reasons it is widely used in cookware and food preservation (cans, bags, foil, etc.). Aluminum's light weight makes it valuable as a building material, as well as a substitute for iron in engine blocks and in aircraft work.

Copper is one of the most useful metals and was, most likely, the first one used by humans. The discovery of copper moved us from the Stone Age into the Bronze Age. Copper is a tough, ductile material. It can be drawn or hammered easily into new shapes without breaking or tearing.

Pure or electrolytic copper is 99.9 percent pure. It is used for electrical conductors and switch contacts, but becomes brittle when heated.

Principal copper alloys are brass, bronze, and nickel silver alloys. *Brass* is a copper-zinc alloy. The alloy can have up to 40 percent zinc. There are many different brasses that have a broad range of properties. Decorative items, lighting fixtures, and plumbing fixtures are often made of brass.

Bronze is any copper alloy that does not have zinc or nickel as the principle alloying element. Typical bronzes are copper-tin bronzes, and aluminum bronzes. Brazing operations use bronze as a bonding material.

Nickel silvers are copper alloyed with zinc and silver. Copper constitutes about 70 percent of the alloy while silver makes up 5 to 30 percent. The balance of the material is zinc. These alloys are used as the base metal for silver-plated dinnerware, springs, electrical connectors, and boat parts.

Other important nonferrous metals are tin and lead. *Tin* is a soft, malleable material that melts at a fairly low temperature. Tin is used as an alloying element and as a coating for steel (such as tinplate for "tin" cans).

Lead is a heavy, soft, malleable metal. Lead is used in storage batteries, a shielding for radiation, and in chemical applications. When combined with tin, lead forms solder that is used in assembling electrical components.

POLYMERIC MATERIALS

Polymeric materials are organic, noncrystalline (without a crystal structure) substances. They are made of many different elements, but carbon and hydrogen always appear in their composition. These elements form long, chain-like molecular structures with a carbon "backbone."

Polymers, as shown in Fig. 3-9, can be divided into two major groups:

- **Natural polymers:** These are materials that occur in a usable form in nature such as wood, wool, and natural rubber (latex).
- **Synthetic polymers (plastics):** These are materials that are synthetically (human designed and produced) created from natural, organic materials such as petroleum, natural gas, or plant fibers.

Natural polymers

There are many natural polymers. One major type is fibers. They are primarily plant fibers and animal hair or hides. Wool and leather are typical animal

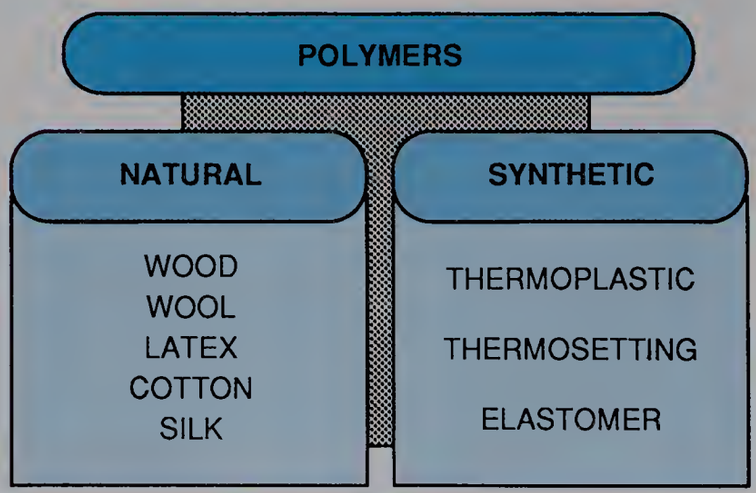


Fig. 3-9. These are types of polymers.

polymeric materials. Cotton and flax are vegetable fibers that are used to produce fabrics.

Wood is the most common natural polymer that is an engineering material. The term, *wood*, is applied to the material derived from trees. Wood, like all vegetable matter, is made up of hollow cellulose fibers. These fibers make up the structure of the material and account for about 70 percent of the volume.

Lignin is nature's glue that holds the cellulose fiber in place. About 20 to 30 percent of wood is lignin. The remaining part of wood is composed of extractives (oils, tannins, coloring agents, etc.) and minerals.

Trees that are standing and have a commercial value are called *timber*. Boards cut from timber are called *lumber*, Fig. 3-10. However, lumber is only one product of trees. Logs are sliced into thin layers to produce *veneer*. The veneer is then used to produce plywood.

Often, small trees and wood waste are ground into chips. The wood chips may be glued into panels of particleboard or flakeboard. Trees may also be digested into their natural parts–lignin and cellulose fibers. The fibers can be used to produce paper and hardboards. As you can see, wood is a very versatile material that is used in many forms.

All wood, no matter how it is used, may be classified into two groups. These are hardwoods and softwoods. These groupings have nothing to do with the hardness or softness of the material. Instead, they are based on the type of tree that produced the wood. **Hardwoods** are cut from broad-leafed, deciduous trees. **Softwoods** are almost always evergreen conifers with needlelike leaves.

Lumber is a major wood product. It is produced in planks (thick, wide, rectangular shapes) and boards (rectangular pieces less that 2″ thick). These materials are *graded* to indicate proper use and quality.

Hardwood lumber is graded according to the number and size of the clear (free of defects) parts that can be cut from a board. This is called yield or cutting grading. The major grades that are available are:

- *FAS (First and Seconds)*: This is the highest commonly available grade. The board is graded on the poorest side and must yield 85 to 90 percent clear cuttings. The clear cuttings must exceed 4″ wide by 5′ long or 3″ wide by 7′ long. The boards must be at least 6″ wide and 8′ long. (Walnut and butternut are graded to a less demanding standard.)
- *FAS 1-Face*: This grade uses the same standard as FAS, but is graded from the poorer side of the board.
- *Selects*: Boards in this grade must meet the FAS 1-Face standard on the better side. The back cannot be worse than the #1 Common grade. The minimum size of the boards is 4″ wide by 6′ long.
- *No. 1 Common*: These boards are graded on the poorer face and must yield 2/3 clear cuttings. These cuttings must be 4″ x 2″ or 3″ by 3′. The minimum board size is 3″ wide by 4′ long.

Softwood lumber is graded in many more classifications. These can be grouped under construction lumber and remanufacture lumber.

- *Construction lumber* is selected to meet the requirements of the construction industry, Fig. 3-11. The board may be classified by construction numbers (No. 1 Construction, No. 2 Construction,



Fig. 3-10. Trees or timber (left) are cut into logs (center) that are processed into lumber (right). (Weyerhaeuser Co.)



Fig. 3-11. This construction worker is using construction lumber and plywood that are both wood products. (Georgia-Pacific Corp.)

etc.) or by a descriptive term (construction, standard, utility).

- *Remanufacture lumber* is used in making doors, windows, moldings, and other similar products. It is generally used for manufactured items that are installed into construction projects. These boards are graded into Selects (C and Better Select and D Select) and Shop or cutting grades (No. 1 Shop, No. 2 Shop, and No. 3 Shop).

Synthetic polymers

Three terms are used to describe the human-made polymers that are in many of the products we use. These terms are polymers, plastics, and synthetic resins. However, **plastics** is becoming the commonly used term to describe this family of materials.

The first plastic was developed over 100 years ago. This material was celluloid and was designed to replace ivory in billiard balls. About 90 years ago, Bakelite was developed by Leo Baekeland. From these early developments have come the world of plastics.

There are two basic types of plastics: thermosets and thermoplastics. This classification is based on the structure of the materials that will be discussed more completely in Chapter 4.

All plastics are made up of base organic chains called monomers. There are over 25 families of monomers including ethylene, vinyl chloride, styrene, propylene, acrylic, phenolic, silicon, and epoxy. From these base materials come many different products. You have probably used polyethylene sandwich bags, assembled polypropylene models, and seen acrylic (Plexiglas) sheets.

Thermoplastics are materials that have polymer chains with few cross-links. This structure allows the chains to move past one another. Thermoplastics, therefore, can be heated and reformed repeatedly. Heat will also cause them to lose their shape. Have you ever seen a phonograph record that was left in the sun? It probably warped and could not be played easily. The record was made of a thermoplastic known as vinyl.

Thermosets have cross-linked polymer chains that are set by heat. Once they are molded, these materials resist heat. The plastic handles on a toaster, iron, or kettle are made from thermoset materials–phenolic.

A third type plastic is an **elastomer**. These materials can be stretched to twice their normal length. They must return quickly to their original size when the stress is released. Natural and synthetic rubbers are common elastomers, Fig. 3-12. Also, rubber and contact cements are elastomer adhesives.

Plastics are the base for what has been called the "material revolution." Wood and metal products are usually designed to meet the characteristics of commonly available materials. However, with plastics, the material is often developed and engineered by chemists to meet specific product needs, Fig. 3-13.

CERAMIC MATERIALS

Ceramic materials are probably the oldest known materials used by humans. They were the foundation material of the Stone Age. This group contains mostly inorganic (metallic), crystalline materials.



Fig. 3-12. These aircraft tires are made from elastomers. (Goodyear Tire Co.)



Fig. 3-13. This engine is being coated with a paint (synthetic polymer) that was engineered for this application. (Ransburg Corp.)



Fig. 3-14. The cutting tool that is producing these chips is a special ceramic abrasive called a carbide. (Inland Steel Co.)

Ceramics are a very large family of materials that include:

- *Clays*: These are naturally occurring sediments composed primarily of alumina and silica. These materials are used to make pottery, brick, pipe, and tiles.
- *Cements*: These are powders that, when mixed with water, set into a solid. The most common cement is Portland cement that is the binder in concrete.
- *Plaster* and *gypsum*: This is a hydrated calcium sulfate mineral used as building plaster and for wallboard. The drywall board used in many homes is a gypsum product.
- *Refractories*: These are ceramic materials that will withstand high temperatures. They are used to make furnace linings and bricks.
- *Abrasives*: These are hard, sharp ceramic particles. Abrasives are generally an oxide or carbide. They may be used loose, adhered to paper or cloth, or bonded into discs or wheels. Abrasives are used to remove, smooth, or polish materials, Fig. 3-14.
- *Glass*: An amorphous (without set structure) material made from fusing silica (sand). Glass is widely used in packaging containers, in dinnerware, and for windows, Fig. 3-15.
- *Porcelain enamel*: A vitrified (fused) ceramic that is extensively used in chemical and electrical applications. Chemistry laboratory equipment and the inside coatings of ovens are often made from porcelain.

Ceramics are the most rigid and least ductile of all materials. They also shatter easily and are very hard. Many ceramics resist chemical action that make them useful for dinnerware, chemical applications, and sanitary ware (sinks, toilets, etc.)



Fig. 3-15. These workers are observing sheet glass being produced by the float method. (PPG Industries)

COMPOSITES

Composites are materials that are receiving much wider use each year. **Composites** are a combination of two or more materials. However, each material retains its original properties. The new combination is designed so that one material overcomes the weakness of another.

Fiberglass is a common composite. The glass fibers (a ceramic) are very strong but highly inflexible. The plastic resin that bonds them in place produces a strong material that can withstand flexing and blows. Another common composite is concrete. It is a mixture of sand and gravel. These materials are bonded into a solid mass by cement. Wood is a natural polymeric composite. As discussed earlier, the base material is cellulose fibers. These are held in place by lignin.

As you can see from these three examples, all composites contain a structural element–glass fibers, gravel, cellulose, etc. A second material holds the structural materials in a fairly rigid position. The resulting material–a composite–has properties that neither component has all by itself.

Composites are used for manufacturing hundreds of products including aircraft, automotive and truck bodies, and shower stalls. See Fig. 3-16.

SUMMARY

Materials are everywhere. These essential building blocks of the world are either gases, liquids, or solids. Solid materials are often called engineering materials. These materials can be separated into three groups: metals, polymers, and ceramics. Within these groups are literally thousands of individual materials. Each of these has a particular set of properties that make them useful for specific uses. The structures of these materials will be discussed in the Chapter 4, while the properties will be explored in Chapter 5.



Fig. 3-16. This artisan is working on a composite body part for an experimental solar powered automobile. (General Motors Corp.)

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

alloy
carbon steels
ceramic materials
composites
elastomers
engineering materials
ferrous metals
hardwoods
high alloy steels
inorganic materials
manufacturing
metallic materials
natural polymers
nonengineering materials
nonferrous metals
ores
organic materials
plastics
polymeric materials
softwoods
synthetic polymers
thermoplastics
thermosets

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. What is the difference between an organic and an inorganic material?
2. What is the difference between an engineering material and a nonengineering material?
3. List and describe the three major types of materials.
4. Generally, pure metals are combined with other metals or inorganic materials to produce an _____.
5. _____ is the fundamental ingredient for all ferrous metals.
6. List the two major types of steel.

7. The most commonly used nonferrous metal is:
   a. Bronze.
   b. Brass.
   c. Aluminum.
   d. Nickel.
8. What is the difference between a hardwood and a softwood?
9. True or False? Plastics is becoming the commonly used term to describe synthetic polymers.
10. True or False? Thermosets can be heated and formed repeatedly.
11. Glass, abrasives, clays, and cements are examples of _____ materials.
12. Which of the following is a common composite?
    a. Lead.
    b. Fiberglass.
    c. Thermoplastic.
    d. Construction lumber.

APPLYING YOUR KNOWLEDGE

1. Identify materials found in a certain product and detemine substitute materials.
   a. Select a common product from either your home or the school technology education laboratory.
   b. Study the product. (It should be one made of several different materials.)
   c. Using a chart similar to the one in Fig. 3-A, identify the materials in the product. (You should be able to identify materials such as metal, ceramic, plastic, or a composite.)
   d. Next, list a substitute for each of the materials used.
2. Collect and label a set of samples that include the following materials:
   a. Natural polymeric composite (wood).
   b. Synthetic polymer (plastic).
   c. Ferrous metal (iron or steel).
   d. Nonferrous metals.
   e. Clay-based ceramic.
   f. Silica-based ceramic (glass).
3. Research the library for information about a new material or a new application of a material.
   a. Go to the periodical section. Search through the contents pages of the magazines for articles on materials.
   b. Prepare a summary of the selected article.
   c. Give a written or oral report to the class.

Product:		
MATERIAL	**TYPE**	**SUBSTITUTE**

Fig. 3-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.

4

CHAPTER

STRUCTURE OF MATERIALS

After studying this chapter, you will be able to:

- *Choose materials based on knowledge of structures.*
- *Distinguish between microstructures and macrostructures.*
- *Describe the structure of atoms.*
- *Explain how to use the periodic table of elements in finding out about material properties.*
- *Describe how the bonding of atoms takes place and list various types of bonds.*
- *List three types of structures in which atoms are arranged.*
- *Give examples of various types of macrostructures.*
- *List and describe four categories of synthetic composites.*

You may be asked to select a material for a task or product. How will you make this decision? On what basis will you choose one material over another? Designers and engineers base their choices on a knowledge of the basic *structure* of a material. This structure determines the properties of the material. It determines how a material reacts to stress, temperatures, chemicals, and many other factors.

The basic nature of materials can be viewed at two levels: microstructures and macrostructures. Examples of these are shown in Fig. 4-1.

MICROSTRUCTURES

The **microstructure** is the way molecules and crystals are arranged in a material. The microstructure is what makes a material uniform. It determines, for example, whether a material is aluminum, steel, or polyethylene. The microstructure is so small that it must be viewed through a microscope.

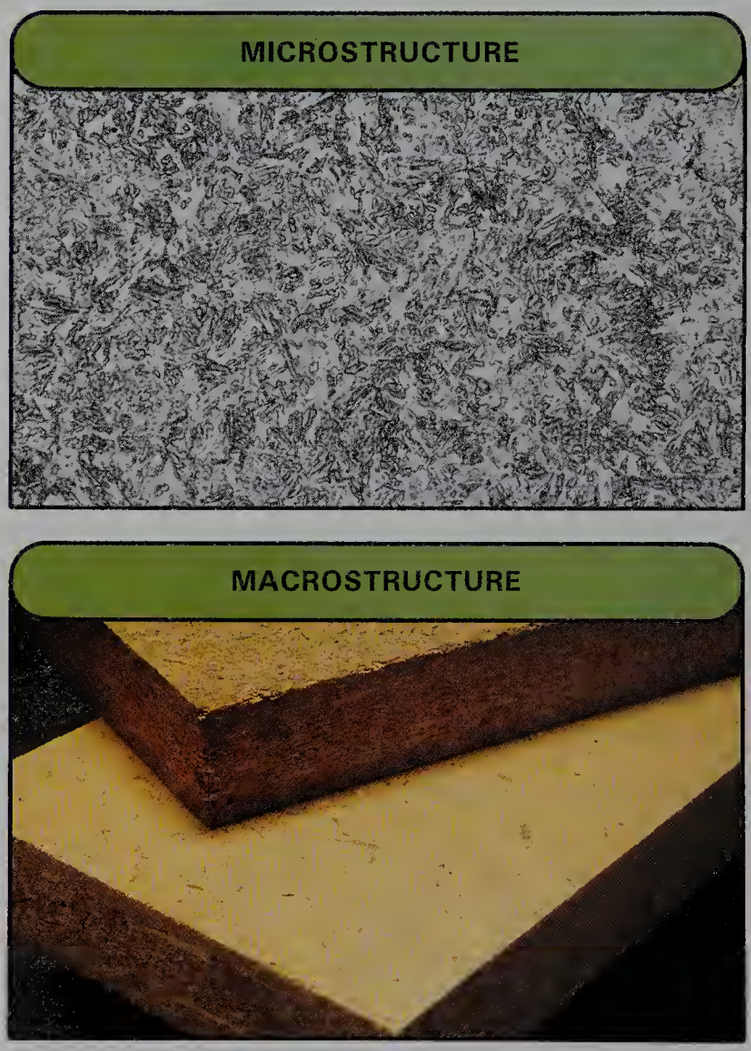


Fig. 4-1. Structure of materials: The view on the top is a microstructure of steel magnified 200 times. On the bottom is a macrostructure showing particleboard. Notice the structures of each. (Bethlehem Steel Corp., Weyerhaeuser Co.)

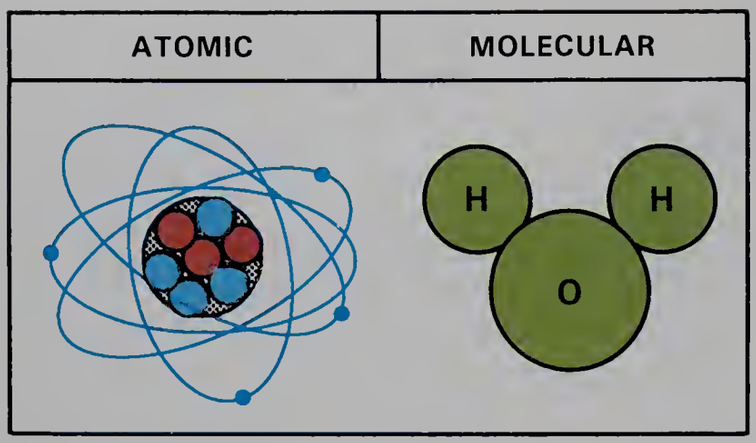


Fig. 4-2. Materials are made up of subatomic particles, which form the atomic structure of atoms. Atoms bond with other atoms and form a molecular structure.

In studying the microstructure of a material, you will learn about the atomic particles that are present and the way they are held together. This structure, as shown in Fig. 4-2, can be studied by exploring the atomic structure and the molecular structure.

ATOMIC STRUCTURE

The **atom** is the basic unit in the study of the microstructures of materials. It was once believed to be the smallest particle that could exist. It was seen as a single unit of mass that could not be further divided.

We now know that the atom is composed of smaller particles. These particles are called *subatomic particles*. There are many types of subatomic matter. Knowing about all of them is not essential to understand materials and their characteristics.

However, some knowledge of atomic theory is vital. It provides insight into the factors that establish material properties. With this knowledge, for instance, you can understand how oxidation (rusting, tarnishing, corrosion), electrical and thermal conductivity or ductility, and fatigue occur.

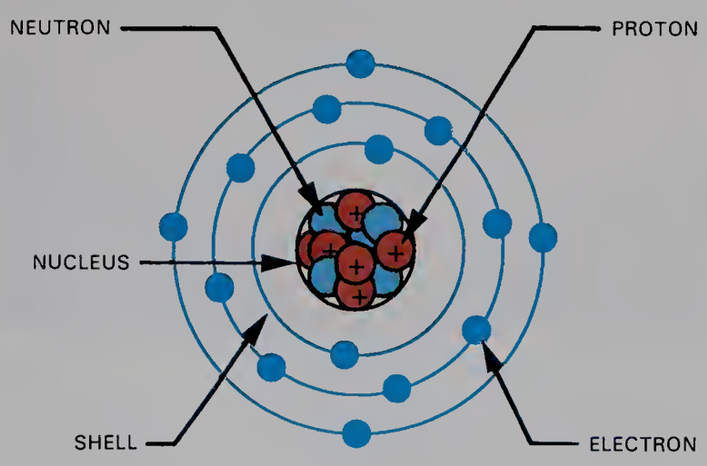


Fig. 4-3. This illustration shows the model of an atom.

STRUCTURE OF ATOMS

Each atom is composed of some basic building blocks. There are electrons, protons, and neutrons. A number of models and equations describe the atom and its structure. The simplest and oldest in present use is *Bohr's atomic model*, Fig. 4-3. Although it does not fully describe the atom, it provides a basic picture of the physical arrangement of the atom. It suggests that all atoms have a series of electrons that orbit a stationary nucleus in set paths.

Electrons

Electrons are subatomic particles that have a negative electrostatic charge. They orbit around the nucleus (center) of the atom. The positively charged proton in the nucleus attracts the electron. This attraction is offset by the centrifugal force created by the moving electron. (Centrifugal force is the action that forces objects outwardly away from a center of rotation.) As a result, each electron has its own path around the nucleus. Several electrons, however, can orbit at approximately the same distance from the nucleus. They are said to be moving in a band or energy level called a *shell*, Fig. 4-4. The shell closest to the nucleus is called the K shell followed outward by the L, M, N, O, P, and Q shells.

Each shell can contain a maximum number of electrons. The number is determined by a simple relationship as shown in Fig. 4-5. The number of electrons in the outer shell is important. It determines how atoms can bond together to form solid materials. The bonding, in turn, helps determine the material's mechanical properties. (These will be discussed in Chapter 5.)

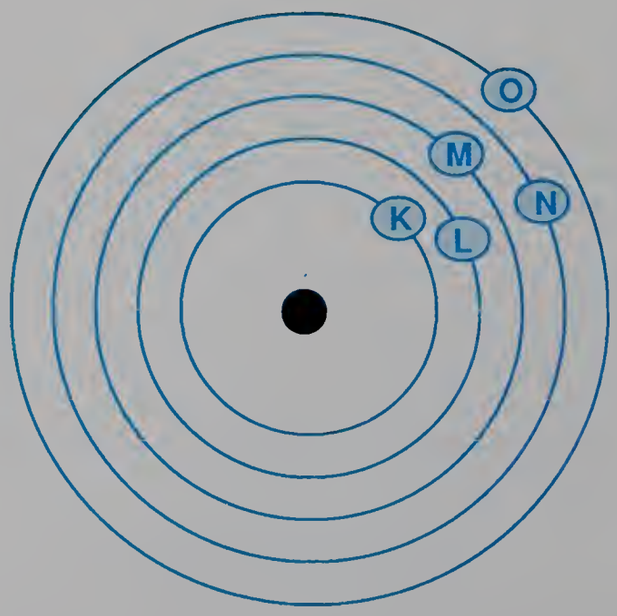


Fig. 4-4. Electron shells or energy levels orbit at approximately the same distance from the nucleus.

SHELL	CALCULATION	MAXIMUM NUMBER OF ELECTRONS
K	2×1^2	2
L	2×2^2	8
M	2×3^2	18
N	2×4^2	32
O	2×5^2	50

Fig. 4-5. Each shell or energy level can contain a maximum number of electrons.

Nucleus

The *nucleus* is the center of the atom. It is made up of several types of subatomic particles. Two of these are the most important and exist in all atoms except hydrogen. They are protons and neutrons.

Protons hold a positive electromagnetic charge, while electrons hold a negative charge. Since like charges repel one another and unlike charges attract each other, the positive charge of protons provides the force that holds electrons in orbit. This action is like the gravity of the sun that holds the earth and other planets in their elliptical orbits.

The *neutrons* are neutral particles. The protons and neutrons provide almost all the mass (weight) of an atom. The electrons add very little weight, but their orbits establish the volume or size of the atom.

Ions

Hydrogen is the simplest atom in nature. It contains one proton and one electron. The electron and the proton have mutual and equal attraction. The result is an electrostatically stable atom.

However, if an atom loses or gains electrons through some action, it becomes an **ion**. An ion is a positively or negatively charged particle. In the case of hydrogen, it becomes a positively charged ion when it loses an electron. The positive charge of the proton in the nucleus is not counterbalanced by a negatively charged electron.

As the hydrogen ion seeks to gain electrostatic balance, it will seek another electron or a negatively charged ion (one that has gained an electron). For instance, if two hydrogen ions find an oxygen ion, a molecule of water (H_20) will form.

THE PERIODIC TABLE

Over the years, a table of elements has been developed. This table, shown in Fig. 4-6, is called the **periodic table of elements**. It is organized around a series of rows and columns.

This table is studied in depth in chemistry classes. In the study of manufacturing, you will be interested in how it deals with material properties. As you study the abbreviated periodic table in Fig. 4-7, you will be able to make some general observations. These include:

- All the elements in the same vertical row will have similar, but not identical, properties.
- The groups in the left portion of the table easily form positively charged ions.
- Elements in the far right column are inert gases. They will not react with other chemicals or dissolve in metals.
- The other elements on the right side form negatively charged ions.
- Elements on the left and bottom portions of the table are metals. They make up the vast majority of the elements.
- Metals on the left portion of the table are called "light metals."
- Metals on the right portion of the table melt at low temperatures.
- Heavy metals can be divided into brittle and ductile groups by their location on the table.

The periodic classification of elements

The chemical activity of each element is determined by two main factors. These are its atomic number and the grouping of electrons in its outer shell.

The grouping of electrons in the outer shell of an element is of special interest to product designers and engineers. It is this grouping that, among other factors, determines:

- The chemical properties of the element.
- The way atoms are bonded together to form solid materials. (This, in turn, determines the mechanical properties of the material.)
- The size of the atom. (This factor is directly related to the material's electrical conductivity.)

Atomic number and weight

All atoms are designated by two numbers as can be seen in the periodic table in Fig. 4-6. The bottom number is the *atomic number*. This number represents the number of electrons present if the atom has not been ionized. The atomic number is also equal to the number of protons in the nucleus. For example, iron (Fe), Fig. 4-8, has an atomic number of 26. Therefore, iron has 26 electrons and 26 protons.

The top number is the *atomic mass number*. This number is equal to the sum of the number of protons and neutrons in the nucleus. For example, the atomic mass for iron is 55.85. The whole number, 55,

Periodic Table of The Elements

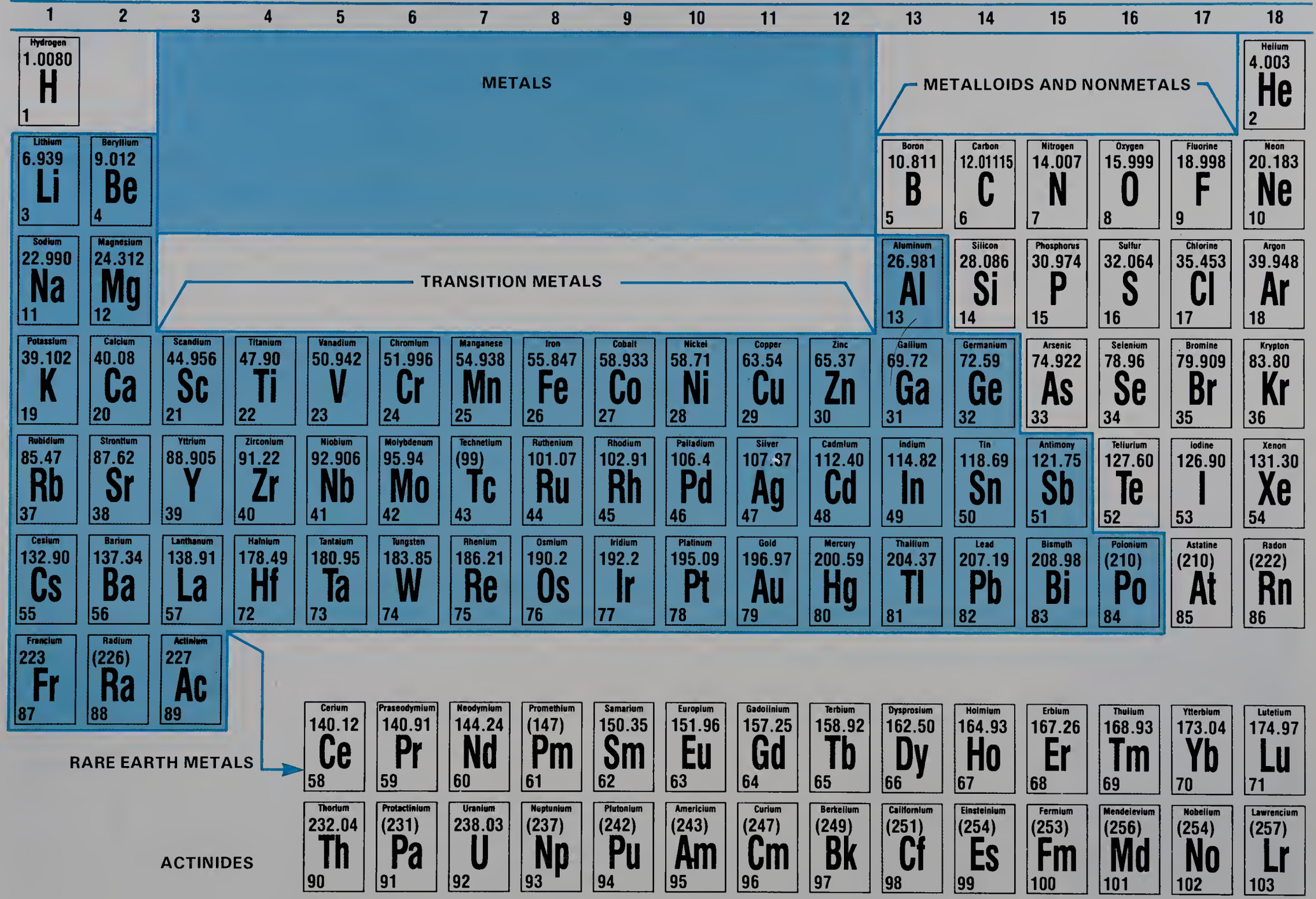


Fig. 4-6. The periodic table of elements is used in the study of both chemistry and manufacturing.

Periodic Table of The Elements

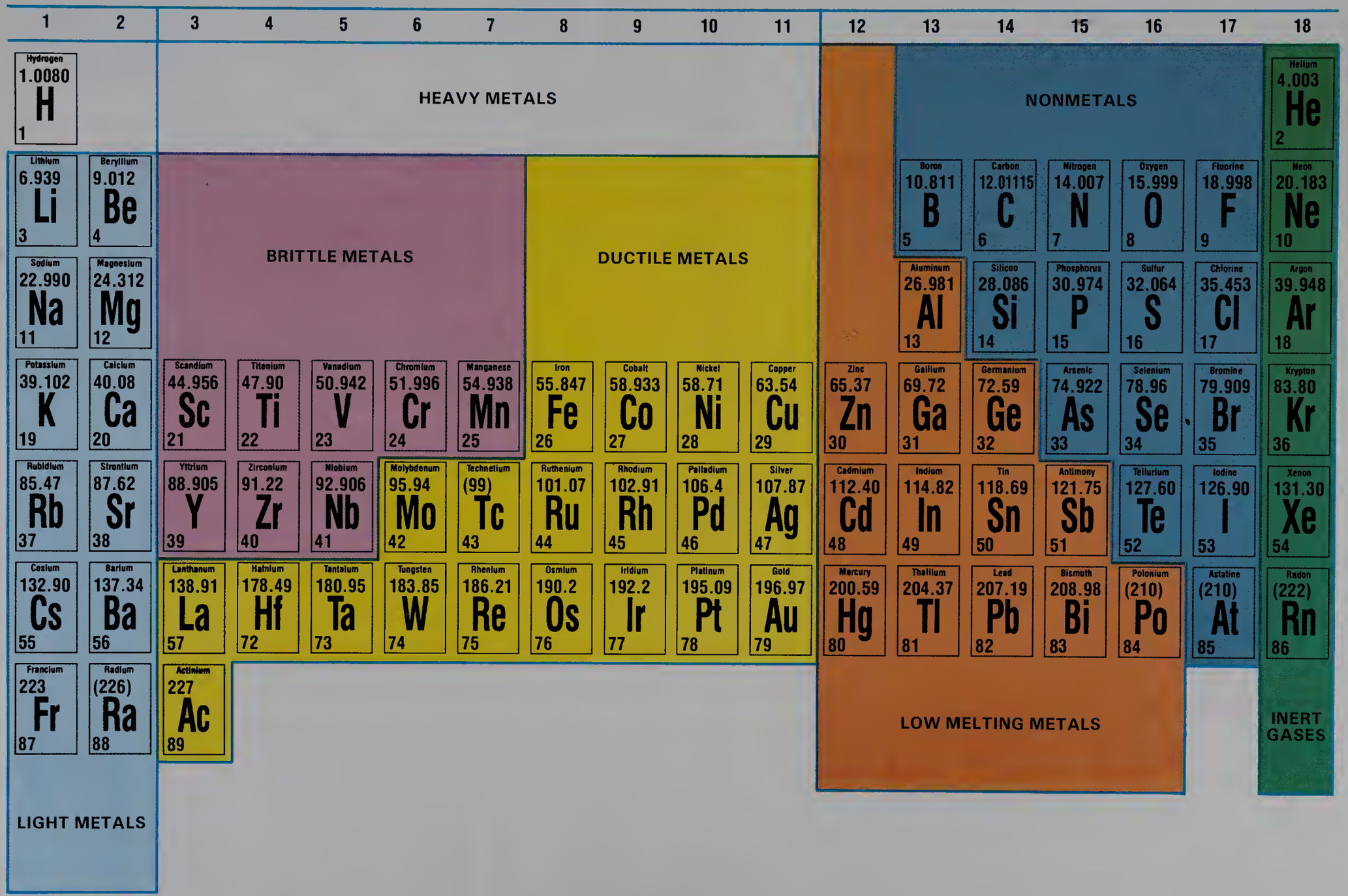


Fig. 4-7. This periodic table of elements divides the elements into major groups according to types and properties.

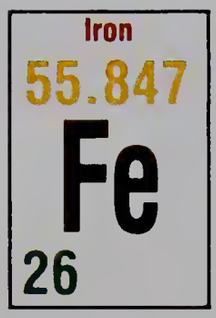


Fig. 4-8. This is a periodic table entry for iron.

represents the number of nucleons (neutrons and protons) present in the nucleus. Since the atomic number of 26 indicates there are 26 protons, there must be 29 neutrons (55 - 26 = 29).

These numbers are important. They describe a "pure" substance. Only iron has 26 electrons and protons and 29 neutrons. No other substance has this combination. These "pure" materials are the basic building blocks for all materials on earth. They are called **elements**. Everything you see around you is composed of fewer than 100 elements that naturally appear on earth.

Elements are stable. Iron does not change into aluminum or manganese or any other element. This stability allows us to:

- Predict the characteristics of pure substances.
- Combine various substances to produce more complex materials.
- Select suitable materials for specific engineering applications.

BONDING

Bonding is an attractive force that holds atoms or ions together. All atoms seek to reach a stable structure. This condition exists when there are eight electrons in the outer energy level (except for hydrogen and helium that need only two). Only the inert gases are normally in this state. Therefore, they do not react or bond to other elements. All other elements are active in varying degrees as they seek stability.

There are three ways atoms can reach structural stability:

- Releasing extra electrons, forming positive ions.
- Receiving extra electrons, forming negative ions.
- Sharing electrons with adjacent atoms.

Primary bonds

The ways atoms reach structural stability are the basis for how atoms bond to form solid materials. They are the foundation for the three primary ways that chemical bonds are developed, Fig. 4-9. These methods, which directly impact a material's properties, are:

- Ionic bonding.
- Covalent bonding.
- Metallic bonding.

Ionic bonding. As discussed earlier, atoms give up or take on electrons to reach structural stability. This action will produce ions. For example, the metal, sodium (Na), must lose the one electron in its outer energy level to reach structural stability. The loss of one electron in its M shell, leaves the L shell as the outer energy level. This shell has the eight electrons that are required for stability. However, the ion now has ten electrons and eleven protons. It is a positively charged ion, Na^+, Fig. 4-10.

Chlorine reaches stability in an opposite action. It has seven electrons in its outer energy shell. It must pick up an electron to become structurally stable. When it gains an electron, its M energy level will have the required eight electrons. However the ion now has 18 electrons and a negative charge, (Cl^-).

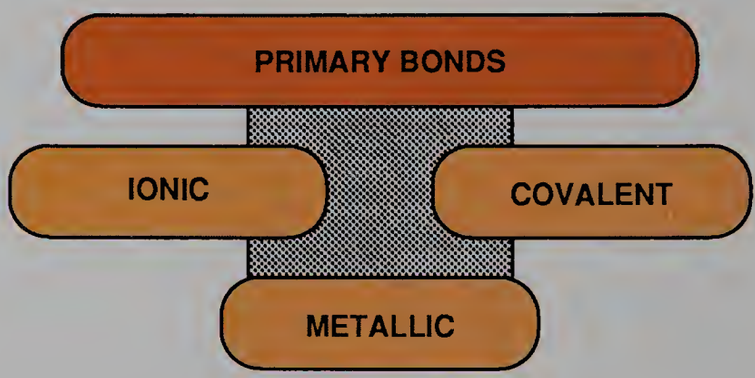


Fig. 4-9. These three primary bonds will directly affect a material's properties.

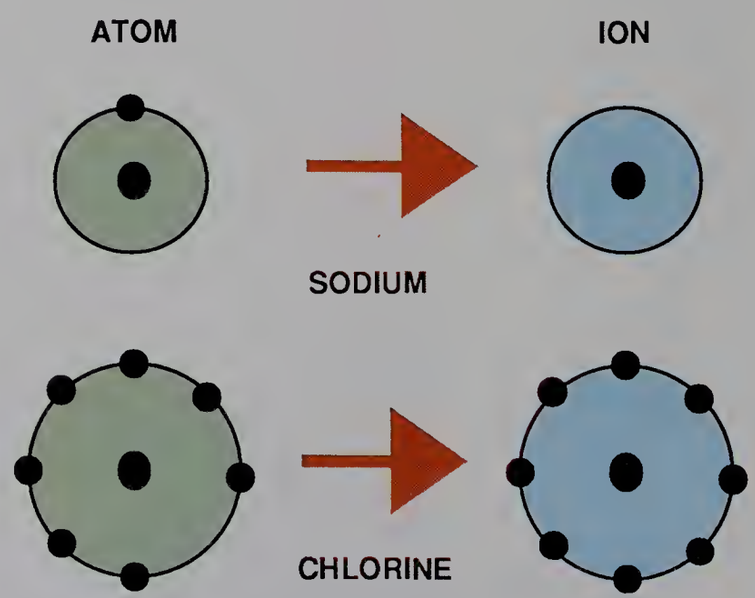


Fig. 4-10. This diagram shows the outer energy levels of sodium and chlorine atoms and ions.

The positively charged sodium ion will attract the negatively charged chlorine ion. This action produces a **compound** (atoms of two or more different elements in definite proportions). You know this resulting material as table salt, NaCl.

However, there will be more than one sodium and one chlorine ion present. Each ion acts the same way. Sodium (positive) ions attract chlorine (negative) ions and repel other sodium ions. Likewise, the chlorine ions attract sodium ions and repel other chlorine ions. These electrostatic forces cause a very uniform and stable structure, Fig. 4-11. The force is called **ionic bonding**.

Ionic bonds are formed between metallic and nonmetallic elements. Metals that have fewer than three electrons in their outer energy levels will become positive ions. The nonmetallic elements will gain electrons from these metals to fill their outer level.

Materials with ionic bonds will dissolve or separate in a solution. They will reform their solid structure when the solvent is removed.

Covalent bonding. The elements toward the center of the periodic table do not ionize easily. Their outer energy levels are half full. Therefore, they do not pick up or lose electrons readily. Instead, these elements share electrons to produce a stable structure. This process is called covalent bonding.

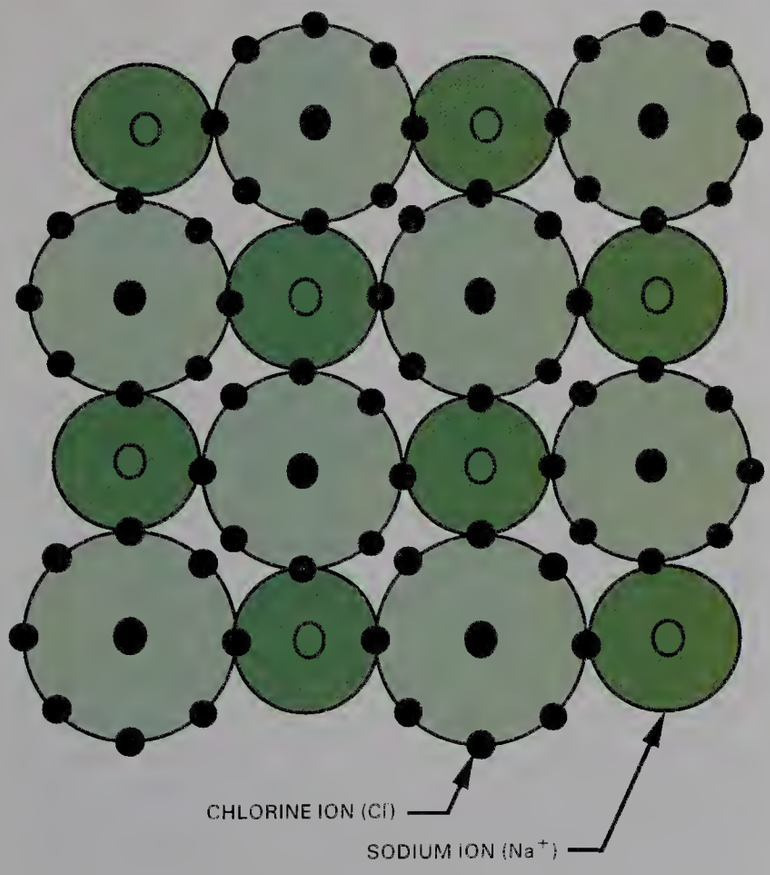


Fig. 4-11. This diagram shows bonding of sodium and chlorine to form table salt.

The simplest example of covalent bonding is hydrogen gas, H_2. Hydrogen has only one energy level. Therefore, it needs two electrons to reach stability. When two hydrogen atoms come close together, the single electron in each atom will act as if it belongs to both atoms, Fig. 4-12. Each atom, by sharing its one electron, gives both atoms a stable K energy electron. Most gases form molecules in this manner.

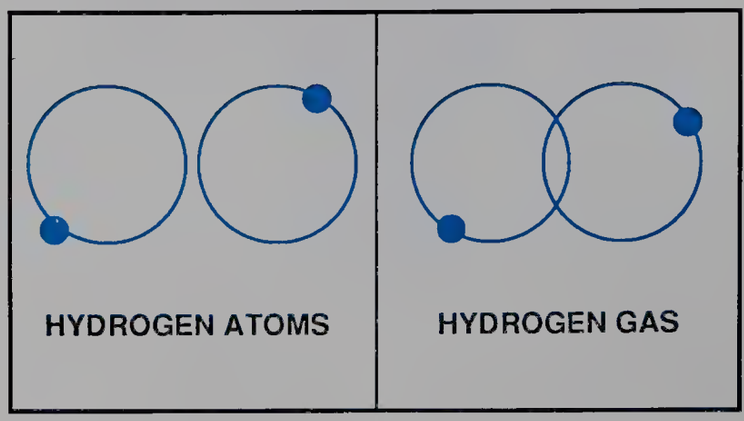


Fig. 4-12. Covalent bonds are formed to produce hydrogen gas.

This principle of covalent bonding is also present in solids. An extremely important element that participates in covalent bonding is carbon. This material is the foundation of all organic compounds.

Carbon can combine with other carbon atoms to form a pure solid. A diamond is an example of a pure carbon compound. Carbon also unites with a large number of other elements. These elements unite with carbon's four covalent links, Fig. 4-13.

Carbon atoms often develop covalent bonds to form chain-like molecules. The base molecule, like the methane one shown in Fig. 4-13, is called a **monomer**. Several monomers are united to form a **polymer**, as shown in Fig. 4-14. Polymers are often called *plastics*.

Metallic bonding. Metallic elements have a common characteristic. They have one to three electrons in their outer energy level. These electrons are only loosely held by the positive charge in the nucleus of the atom.

These loosely bonded electrons are easily separated from an atom. They form what is called an *electron cloud* or *electron gas*.

Structurally stable metallic ions are formed as the electrons leave the atoms and enter the common electron cloud. These ions have a positive charge. The electron cloud has a negative charge. The electrons in the cloud repel each other causing them to be evenly spaced. Likewise, the metallic ions are spaced evenly

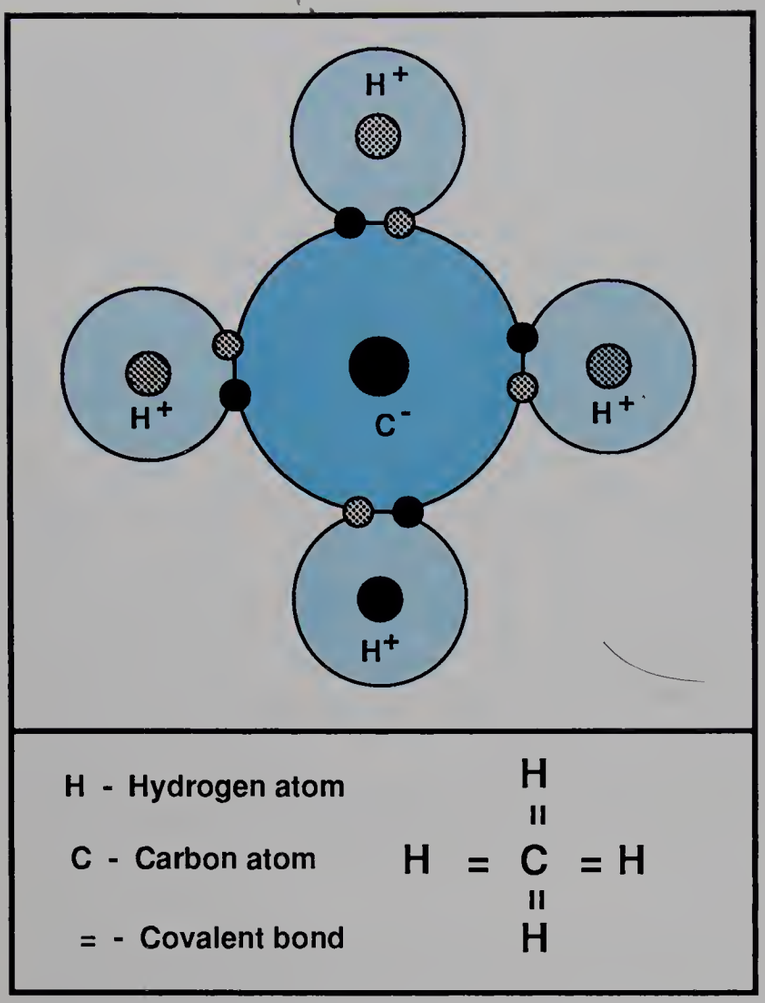


Fig. 4-13. Methane is produced by covalent bonds between one carbon and four hydrogen atoms. The top drawing shows the shared electrons. The bottom drawing shows the common way to diagram organic compounds.

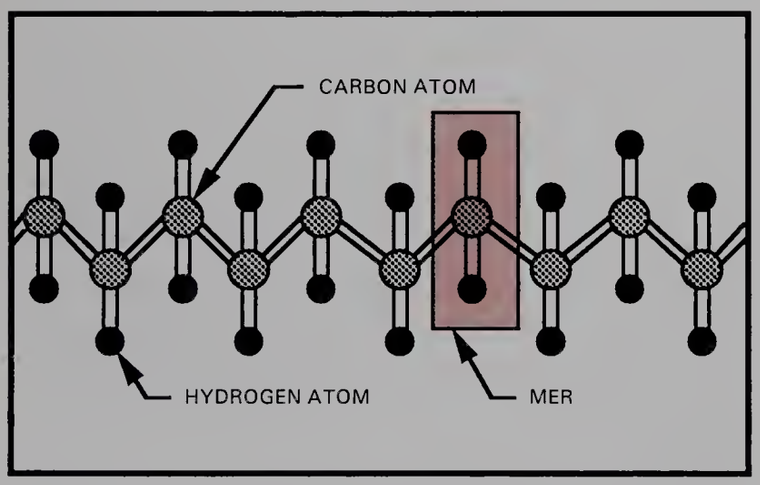


Fig. 4-14. This diagram of polyethylene shows a single ethylene monomer and a portion of the polymer chain.

due to the repelling positive charges. However, the negative charge of the free electrons and the positive charge of the ions create an attracting force. This combination of repelling and attracting forces, called **metallic bonding**, produces a very rigid structure. It contains positive metallic ions suspended uniformly in a cloud of electrons, Fig. 4-15.

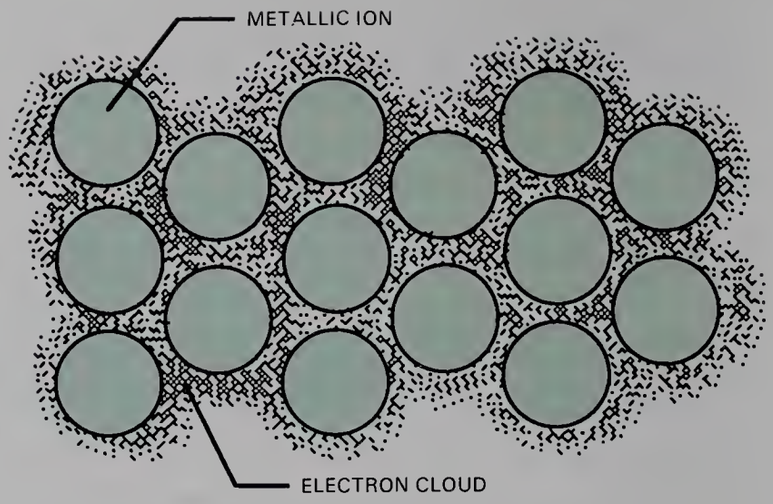


Fig. 4-15. Metals are formed with positively charged metallic ions suspended in a negatively charged electron cloud.

Secondary bonds

There are other bonding forces besides the three primary bonds. The major secondary bond is called **van der Waals forces**. These forces are present to some extent in all materials. However, they are important in understanding plastics.

The skeleton of a plastic is composed of carbon and other elements. They are covalently bonded into polymer chains. The electrostatic charge along the chain is not uniform. At one point, it may be somewhat positive. At another point, it may be slightly negative. This variation in charge will cause the chains to attract one another, forming the solid material.

If the van der Waals forces holding the chains are strong, the material is a *thermoset*. Weaker bonds form *thermoplastic* materials.

ARRANGEMENT OF ATOMS

The atoms of all materials are arranged in some manner. This arrangement gives the material its properties. From a microstructural point, atoms are arranged in three ways:

- Molecular.
- Crystalline.
- Amorphic.

Molecular structures

Molecular structures of solid materials generally use covalent bonds. The structure is polymeric in nature. The material is made up of a number of *mers*. These basic units are chemically united to form *poly-*

mers (many mers). The result is a very complex, chain-like structure, Fig. 4-16.

These structures are common for plastics, wood fibers, and natural rubber. Each of these materials is composed of millions of polymeric chains.

Crystalline structures

Metals and most ceramic material have **crystalline structures**. The atoms, like those in molecular structures, are arranged in a regular pattern. They form three-dimensional boxlike structures called unit cells or crystals. There are 14 possible crystalline structures. Of these, three are the most common. They include the structures of most metals. These, as shown in Fig. 4-17, are:

- Face-centered cubic–FCC.
- Body centered cubic–BCC.
- Hexagonal close packed–HCP.

Each crystal has a simplest form. It is called the *unit cell*. These cells can combine to form larger structures. Each unit cell always retains its basic three-dimensional structure that is called a *crystal lattice*. This lattice is sometimes simply called a *crystal*.

Crystals unite during the cooling of liquid metals to produce grains of materials. These grains interconnect to form the solid structure. Look back to Fig. 4-1. You will see that the grains form in a random pattern. The surface between the grains is called the *grain boundaries*. It is along these boundaries that materials separate or fracture. The ease with which this happens determines the machinability and strength of the material.

Amorphous structures

Amorphous means "without form." This does not mean a material with an **amorphous structure** does not have size and shape. It does mean that the internal structure does not follow any pattern. There is no regular, repeating pattern of the atoms in the material.

All liquids and molten metals are amorphous materials. Glass is the most important amorphous engineering material.

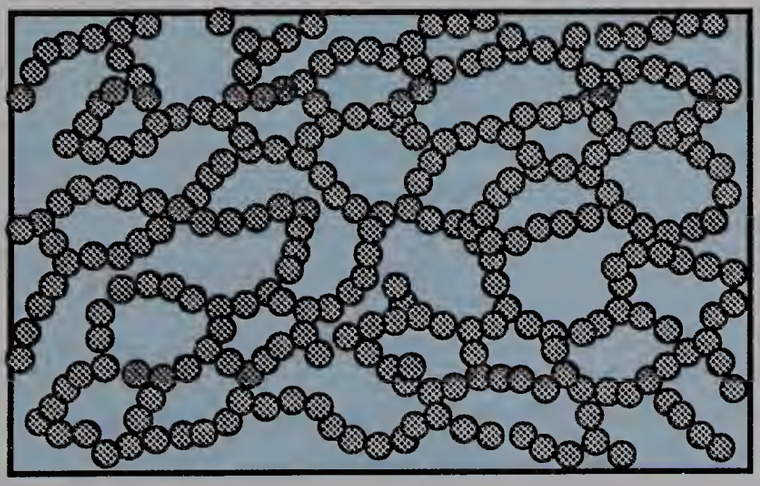


Fig. 4-16. The coiled arrangement of mers is typical of polymeric materials.

MACROSTRUCTURE

A material can be viewed from its microstructure–its very small structural pattern. However, that only tells part of the story. A material also has a macrostructure. The **macrostructure** is the way different substances unite to form complex materials called composites. These materials, as discussed in Chapter 3, are made up of at least two different substances. Each of these substances retains its own properties. Quite often composites can be separated into their basic components. These components will still exhibit their original characteristics.

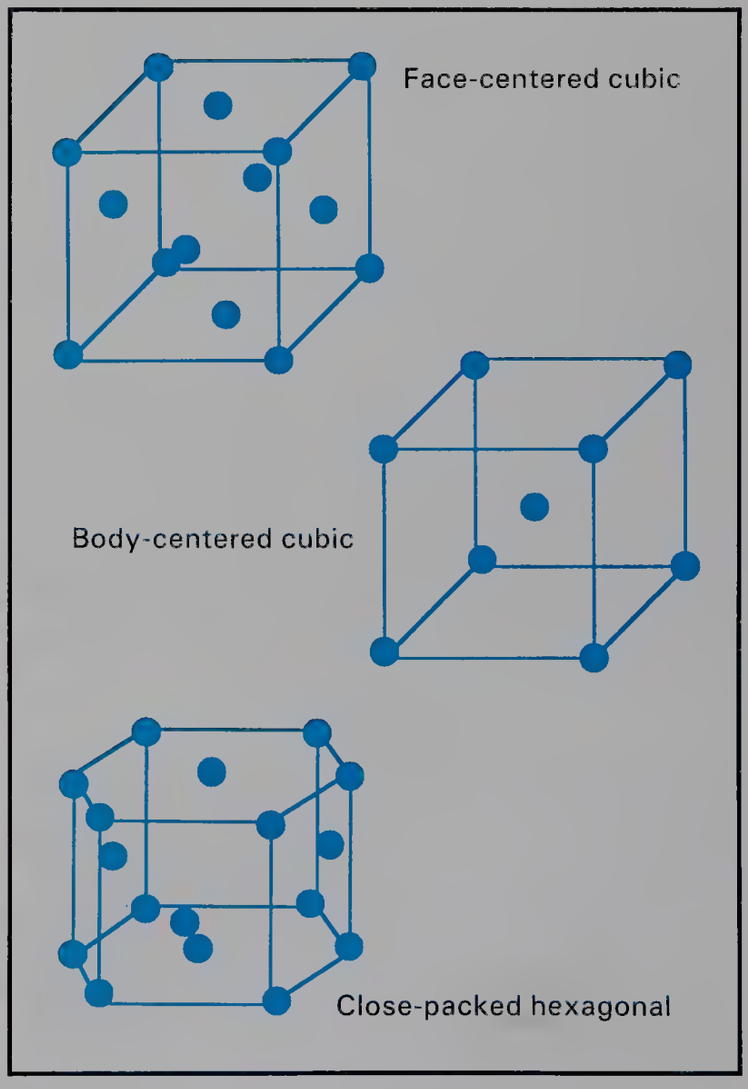


Fig. 4-17. These are the three most common crystal structures for metals.

A macrostructure can be viewed from a large view. For example, plywood is a series of layers of veneer glued together. The wood, as the veneer, has a microstructure. However, the plywood has its own macrostructure. There is a relationship between the layers of veneer and the adhesive that bond them into a single panel.

Concrete is an aggregate (sand and gravel) bonded into a solid by cement. Again, we can view each component's microstructure. However, to understand concrete, we must study its macrostructure.

These materials, as discussed earlier, are called composites. Each material retains its own properties. They are held in place in an external mechanical way. The plywood is held by adhesive forces. The same is true of concrete.

Once materials form a composite, the new combination has its own unique properties. These are often the best of the base material's characteristics. Composites are made up of particles, fibers, flakes, layers, and fillers. Their structure is large and can be seen with the unaided eye.

Composites can be both natural or human-made (synthetic). A common natural composite is wood. From wood, people make a number of synthetic composites. These include plywood, particleboard, and hardboard.

Synthetic composites can be grouped into four categories:

- **Laminate composites**: These are made from layers of material. Typical examples are plywood and six-ply posterboard.
- **Particle composites**: These are made from particles or flakes of material. Typical examples are particleboard, concrete, and flakeboard.
- **Fiber composites**: These are made from fibers of materials. A typical example is hardboard.
- **Dispersed or filler composites**: These are made from a skeleton that is filled with another material. A typical example is a fiberglass panel.

SUMMARY

The properties of materials are determined by their internal structure. This structure may be viewed from the microstructure or macrostructure. The smallest microstructure is the atom. From there, the molecular structure can be studied. This view tells us how atoms combine to form solid materials. This is done through bonding processes. The three bonding methods are ionic, covalent, and metallic.

From an engineering material view, covalent and metallic bonds are most important. Covalent bonding is present in organic materials, while metals are formed through metallic bonds.

The macrostructure approach explains the characteristics of composites. These materials are formed from layers, fibers, particles, and filled structures.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

amorphous structure
atom
bonding
compound
crystalline structures
dispersed or filler composites
elements
fiber composites
ion
ionic bonding
laminate composites
macrostructure
metallic bonding
microstructure
molecular structures
monomer
particle composites
periodic table of elements
polymer
van der Waals forces

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. What is the difference between a microstructure and a macrostructure?
2. Explain why some knowledge of atomic theory is vital.
3. List the three building blocks of an atom.
4. What is the difference between the atomic number and the mass number?
5. True or False? In the periodic table of elements, all the elements in the same vertical row will have similar, but not identical properties.
6. List and describe the three types of bonding discussed in the chapter.
7. True or False? Several monomers are united to form a polymer.
8. True or False? Metals and most ceramic materials have amorphous structures.
9. Give three examples of macrostructures.
10. List four categories of synthetic composites.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Collect samples of three composite materials (such as concrete, fiberglass, plywood, particleboard, or hardboard).
   a. Review information from Fig. 4-1 to fix in your mind the meaning of "macrostructure." Also review information from this chapter on the topic.
   b. Study each of the samples collected.
   c. Construct a chart similar to the one shown in Fig. 4-A.
   d. Describe each material's macrostructure. (For example, are the material parts in sheets, irregular in shape, fine particles or granules, solid or plastic? Are they fastened mechanically or chemically?)
   e. Sketch the macrostructure of each sample.
2. Produce a concrete brick like the one shown in Fig. 4-B. Describe the basic material needed to produce it and sketch its macrostructure.

MATERIAL	DESCRIPTION	SKETCH
1.		
2.		
3.		

Fig. 4-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.

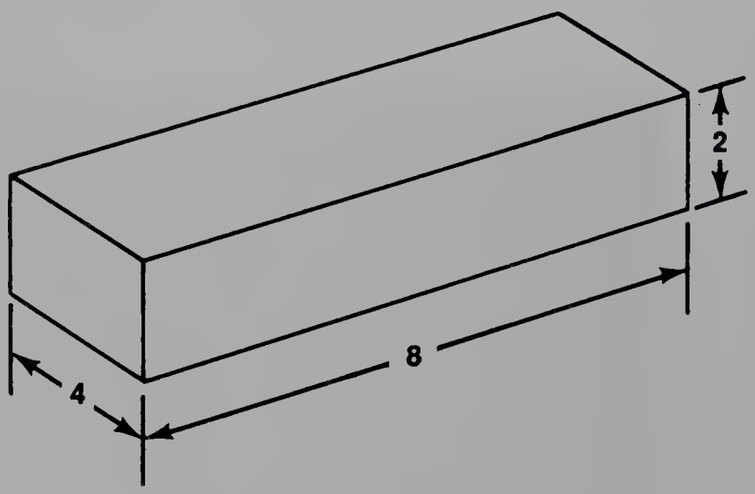
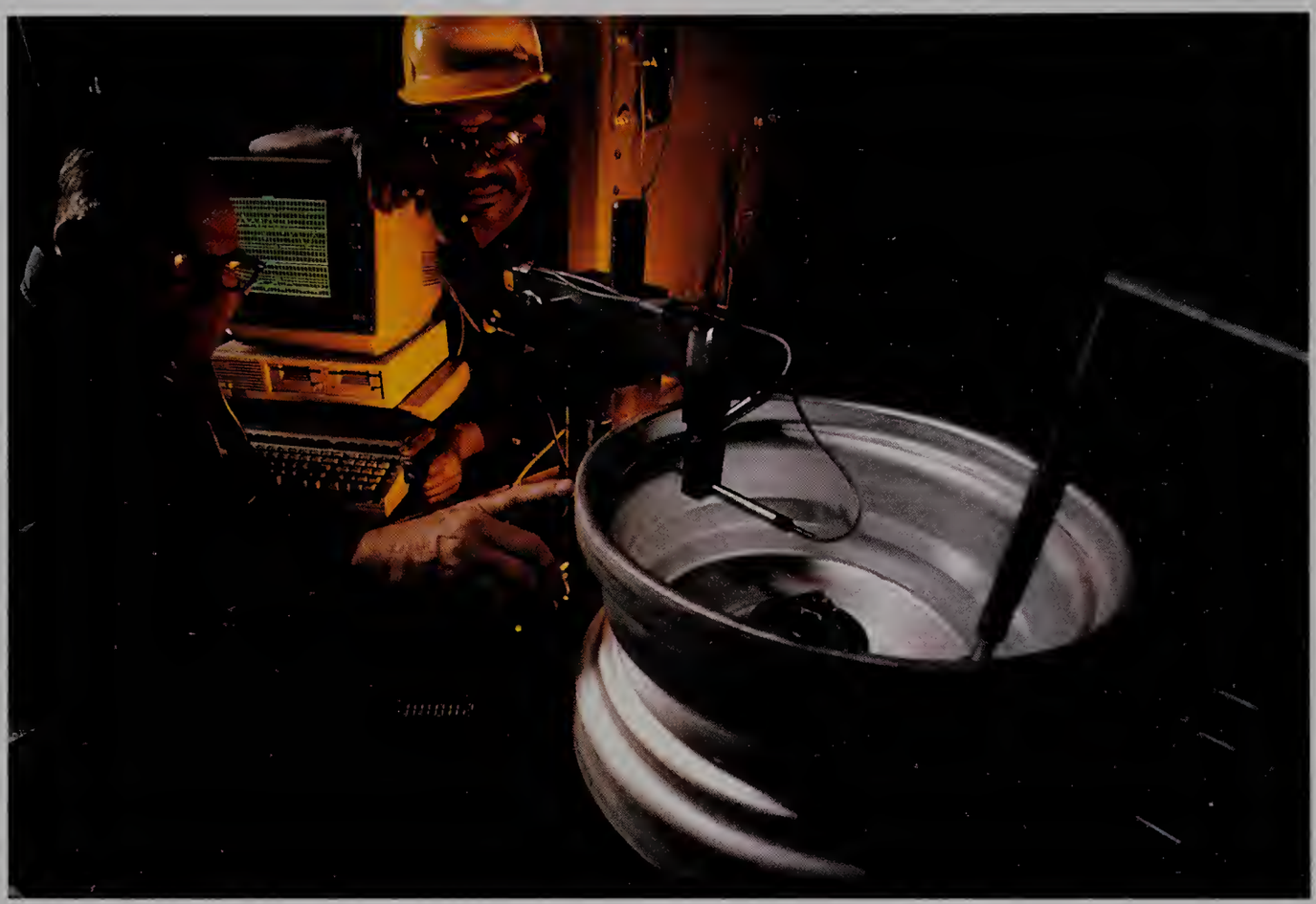


Fig. 4-B. Produce a brick like this one and sketch its macrostructure.



The aluminum alloy used in this forged truck wheel was chosen because of its unique properties. (Mark Godfrey, Aluminum Company of America)

5

CHAPTER

MATERIAL PROPERTIES

After studying this chapter, you will be able to:

- *Select materials based on an understanding of various properties.*
- *Identify the seven major types of material properties.*
- *Name six characteristics that make up the physical properties of a material.*
- *Describe how mechanical properties can affect the way a material will react to an applied force or load.*
- *Cite examples of how chemical properties can affect a material's performance.*
- *List five thermal properties that can affect materials.*
- *Describe electrical and magnetic properties of materials.*
- *Explain how acoustical properties can affect material selection.*
- *Name the three general optical properties.*

As you studied earlier, electrons, protons, and neutrons are the base of all matter. The number of these particles in each atom determines what material the matter forms. For instance, aluminum has a different atomic structure than iron has. This atomic structure establishes the material's properties.

These properties are the major factor that distinguishes one material from another. We do not count electrons to decide what material to use. Instead, we study its properties. **Properties** are traits or qualities that are specific to a certain material.

Material properties are matched with use or service conditions. A material must perform in the natural environment that is full of chemicals. Pollutants attack many materials. The oxygen in the air reacts with metals to cause corrosion. Water (rain and snow) causes steel to rust, and it causes wood to warp. Plastics are attacked by radiation from the sun. What may seem like a neutral environment to you, can be harsh on materials.

Materials must also function under varying temperatures. In many areas, temperatures may rise past 100°F in the summer. Then in winter, they may plummet to well below zero. The paint on your car, the doors on your home, and the shoes on your feet must do their job in this wide range of temperatures. However, this range is small compared to internal parts in automobile and jet aircraft engines. Think of the demands temperature changes place on materials.

These two factors are just examples. A material is subjected to countless forces as it is used to complete a task, Fig. 5-1.



Fig. 5-1. The materials used in this lawnmower were selected to meet the forces and other factors present as the owner uses the product. (Deere and Co.)

SELECTING MATERIALS

Wise material selection, as shown in Fig. 5-2, is based on an understanding of various properties. These characteristics are determined by the internal structure of the material. You studied these structures in Chapter 4.

All products are carefully designed to meet a human need or want. The designer considers the function of the product. Then various mechanisms and parts are engineered. Selecting the right material is an important function of engineering. From the thousands of materials available, the designer must select the one best suited to each application. The wrong choice can be very costly.

As an example, a major sash and door company manufactured windows with insulated glass. The window pane consisted of two sheets of glass that formed an envelope. A gas was sealed between the two sheets. The manufacturer purchased the glass unit from another company and installed it in their wood frames. The glass supplier recommended a change in the gas between the glass. The suggestion was followed. However, it was discovered that the gas reacted with sunlight. Over time, the reaction caused the glass to discolor, forming what is called "blue glass." These windows had to be replaced at a high cost to the glass manufacturer. The mistake was costly, but it did not physically harm anyone.

In another example, a poor selection of welding materials caused the weld to fail in World War II cargo ships. The ships broke up in the rough seas. This mistake was costly in terms of human life.

The selection of materials cannot be taken lightly. The lives of customers and the reputation of the company may be at stake.

TYPES OF MATERIAL PROPERTIES

To help engineers select materials, the properties have been grouped into seven major types:

- Physical.
- Mechanical.
- Chemical.
- Thermal.
- Electrical and magnetic.
- Acoustical.
- Optical.

Each of these properties is unique. It describes certain characteristics of a material. Also, there are common ways to measure and evaluate these properties. Let's look at each of these properties independently.

PHYSICAL PROPERTIES

The **physical properties** of a material include several characteristics, Fig. 5-3. These include:

- Structure.
- Density.
- Moisture content.
- Porosity.

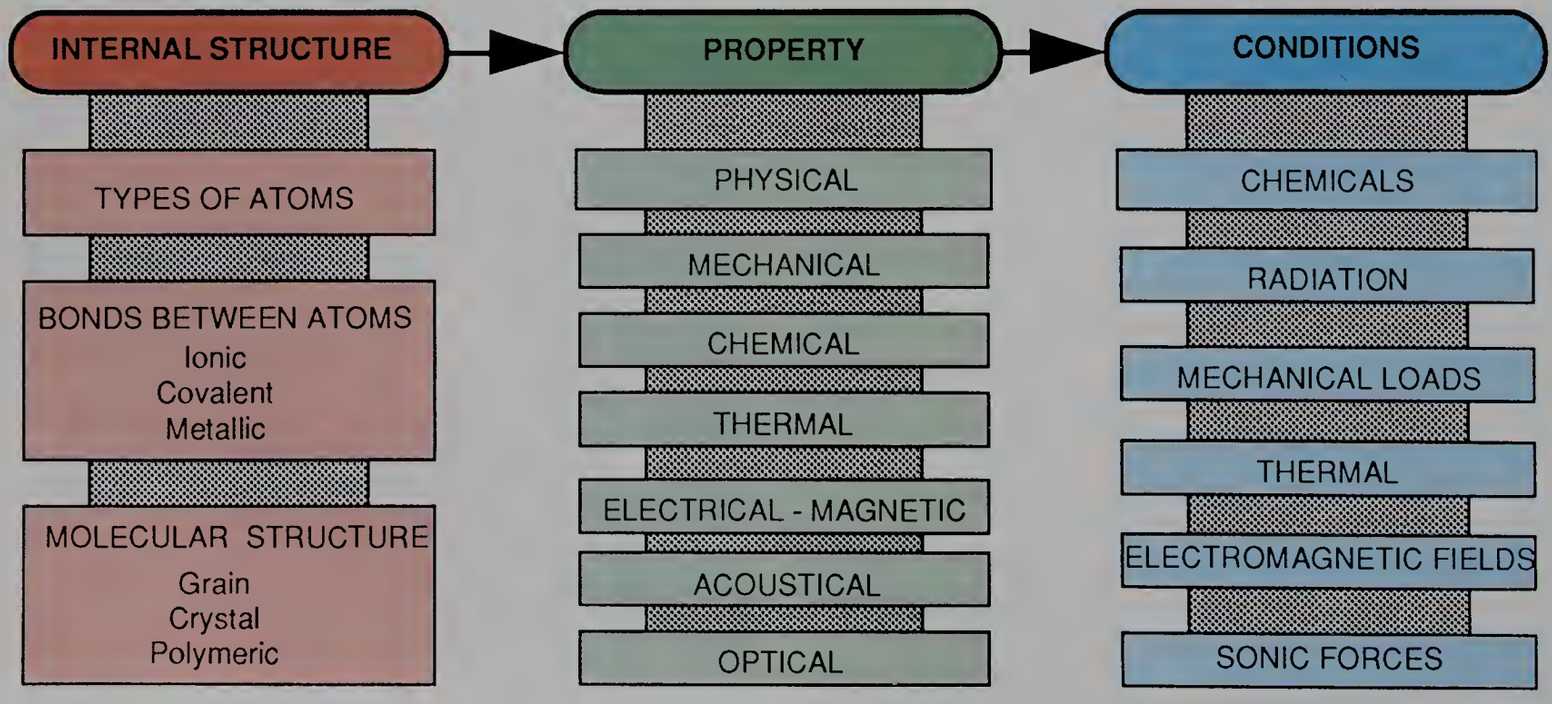


Fig. 5-2. The internal structure determines a material's properties that, in turn, determine how well a product performs under use.

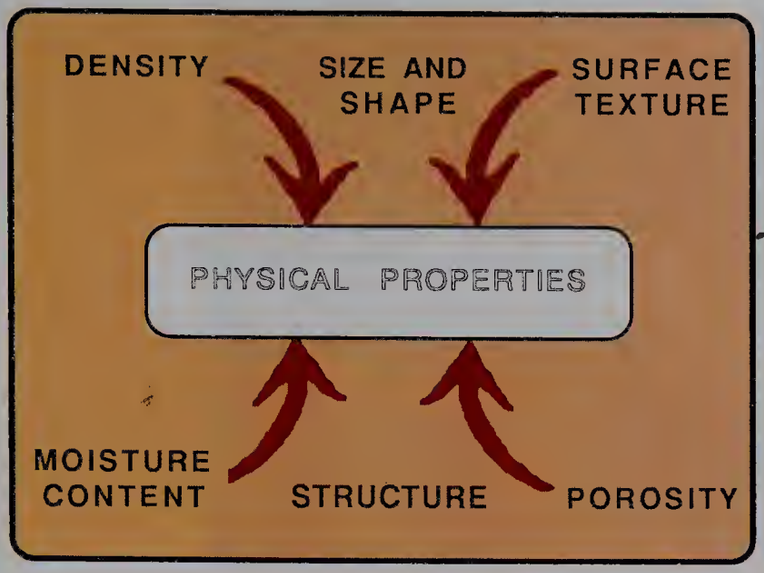


Fig. 5-3. These are some typical physical properties.

- Size and shape.
- Surface texture.

Structure was discussed in Chapter 4. The structure of a material includes its atomic and molecular structure (microstructure) and its visible structure (macrostructure).

Density is a measure of the mass of a material. Density is measured in mass per unit volume–pounds per cubic foot (lb/ft3) or kilograms per cubic meter (kg/m3). This measure allows you to compare the weights of various materials. Something made from a very dense material will weigh more than it would if it were made from a less dense material. For example, an engine block made from cast iron would weigh more than the same one made from aluminum.

Often, the density of a material is compared to that of water. This comparison gives you an index number that allows direct comparisons between materials. This measure is relative density and is often called *specific gravity*.

Moisture content is a measure of the amount of water trapped within a material's structure. The moisture content is defined as the weight of water as a percentage of the moisture-free weight of the material. It can be calculated using the following formula:

$$\text{Moisture content (\%)} = \frac{\text{Weight of the water}}{\text{Oven dry weight}} \times 100$$

Moisture content is an important measure, especially for wood products, Fig. 5-4. It provides the base for calculating the amount of expansion and contraction that can be expected as the wood adjusts to the environment. The moisture content of green (freshly sawed) lumber can range above 225 percent for western red cedar sapwood to about 35 percent for Douglas fir heartwood.

Framing lumber (2 x 4s, 2 x 6s, etc.) used for construction purposes is dried to 15 to 19 percent moisture. Lumber for furniture and interior trim is dried to a 6 to 10 percent range. As this lumber dries, it shrinks considerably. The volume of a hardwood board will shrink between 13 and 17 percent. Softwood lumbers will lose from 7 to 12.5 percent of their volume during drying.

Porosity is the ability of a material to absorb air or water. A porous material, such as paper or cotton, will absorb moisture or air. Also, many porous materials will allow air and water to pass through them. For example, a cleaning sponge must be porous so it can absorb liquids. Filters must allow fluids to pass through them while trapping unwanted solid particles.

All materials occupy space, Fig. 5-5. Engineering materials have rigid structures and, therefore, have specific *sizes* and *shapes*. These are important properties. In fact, changing these properties is a major goal of manufacturing activities.

Surface texture refers to the way a surface of a material looks or feels. In some cases, a smooth surface is desired. Furniture and automobiles have smooth surfaces so their finish coatings have a high gloss. In other cases, a textured surface may be desired. For example, stainless steel sinks have a brushed surface so that scratches will be less noticeable.

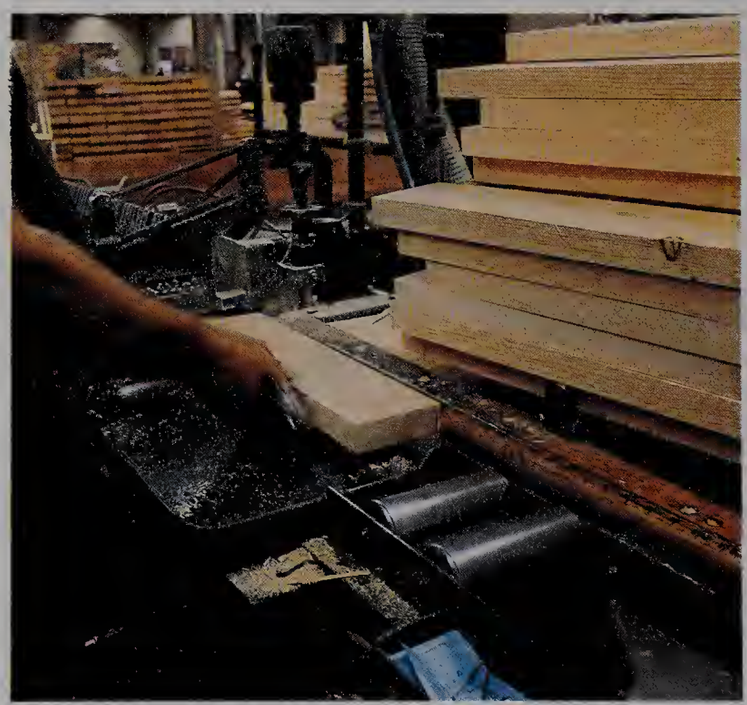


Fig. 5-4. These boards must have low moisture content to reduce warpage and shrinkage.



Fig. 5-5. Consider the physical properties that you can see that are exhibited by these steel plates–size, shape, and surface texture. (American Iron and Steel Institute.)

MECHANICAL PROPERTIES

Mechanical properties govern how a material will react to a force or load. The mechanical properties of a material are determined by three factors, Fig. 5-6:

- Type of bonding.
- Structural arrangement of atoms or molecules.
- Number and types of imperfections in the materials.

This last factor is largely determined during the primary processing phase of manufacturing. Materials of the same chemical composition can vary greatly due to improper control of basic refining actions.

There are five major mechanical properties, as shown in Fig. 5-7. These include:

- Strength.
- Plasticity.
- Ductility.
- Elasticity.
- Hardness.

Strength is the ability of a material to resist forces applied to it. This property determines a material's ability to retain its size and shape and to resist fracturing (breaking). Typically, a part can have four major forces applied to it. These, as shown in Fig. 5-8, are:

- Compression forces: These forces squeeze the material. The resistance to this type of force is called **compression strength**.
- Tension forces: These forces try to pull the material apart. The resistance to them is called **tensile strength**.
- Shear forces: These are opposing forces that tend to fracture the material along grain lines. The resistance to this force is called **shear strength**.
- Torsion forces: These forces twist the material around an axis. The resistance to the force is called **torsion strength**.

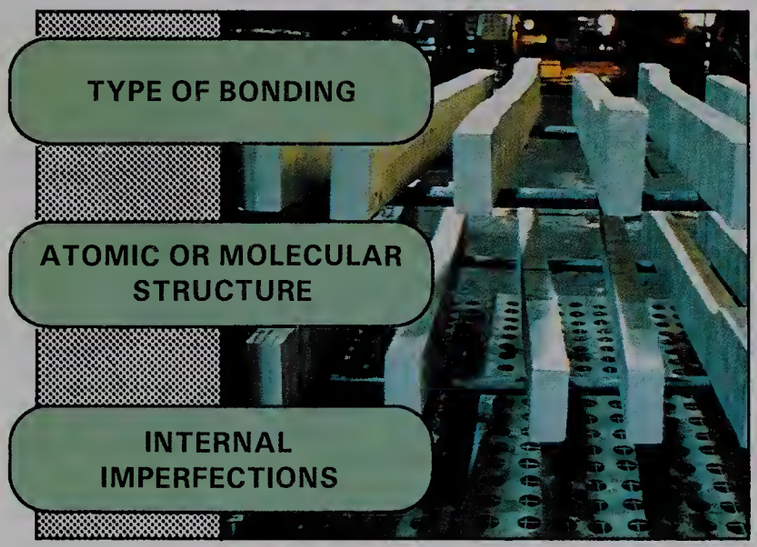


Fig. 5-6. These factors determine mechanical properties of materials. (ALCOA)

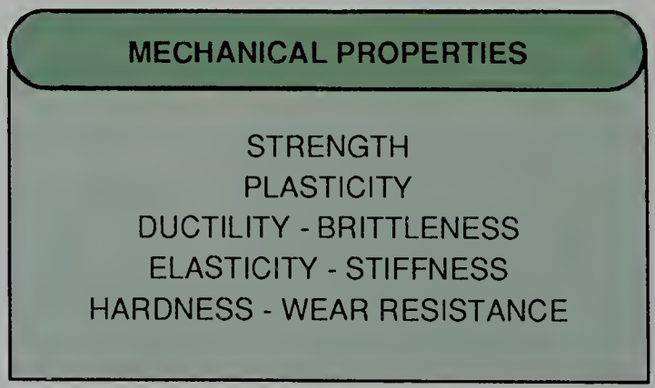


Fig. 5-7. These are common mechanical properties of materials.

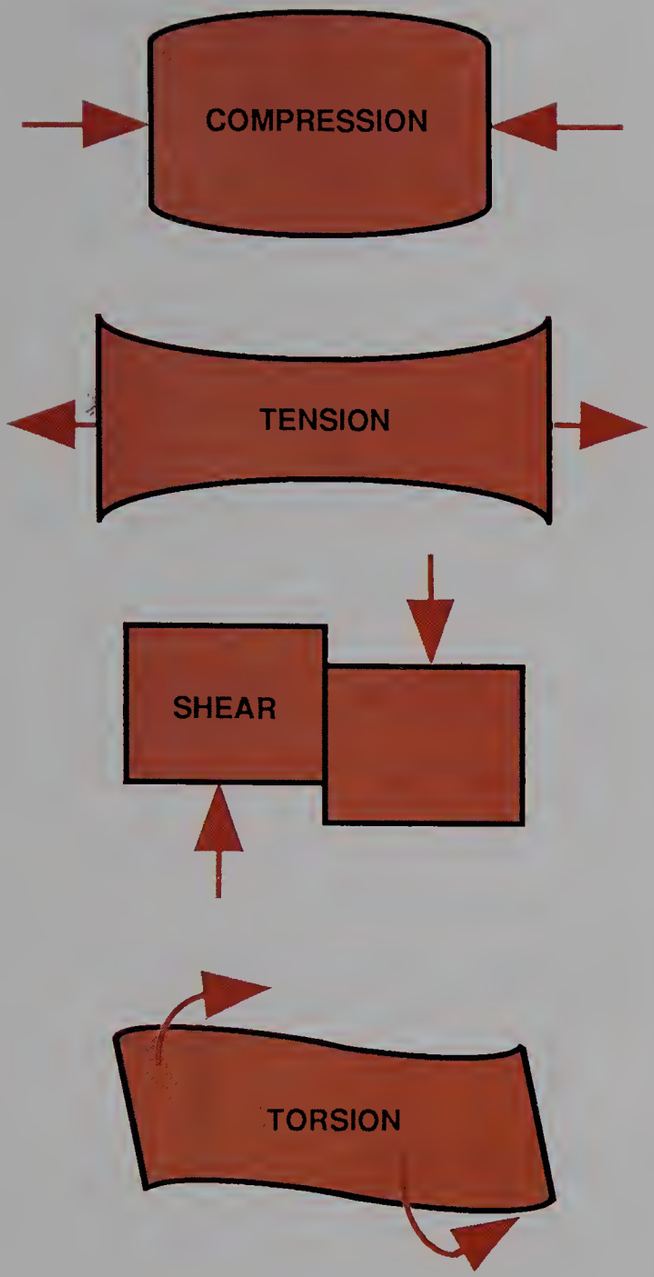


Fig. 5-8. Various types of forces can be applied to materials.

Another important mechanical property is **plasticity**. It is a material's ability to flow into a new shape under pressure. This characteristic is important to forming processes. Plasticity allows a material to take a new shape when a die or roll applies force.

Two other properties are associated with the plasticity of a material. These are ductility and brittleness.

Ductility is the ability of a material to undergo plastic deformation without rupturing. Materials that are ductile are said to have high malleability, workability, or formability.

Brittleness is a measure of the lack of resistance to force. Brittle material will fracture when forces are applied. Glass, cement, and very hard metals are brittle.

Elasticity is the ability of a material to undergo compression or stretching without permanent deformation. Elastic materials are able to return to their original shapes after an outside force is removed. See Fig. 5-9.

Strength, ductility, elasticity, and brittleness are easily shown in a *stress-strain diagram*, Fig. 5-10. As force is applied to a material, it deforms. It will stretch, compress, or bend. This action builds stress in the material structure. Low levels of force will



Fig. 5-9. The synthetic rubber in these tires has a large elastic range. (Goodyear Tire and Rubber Co.)

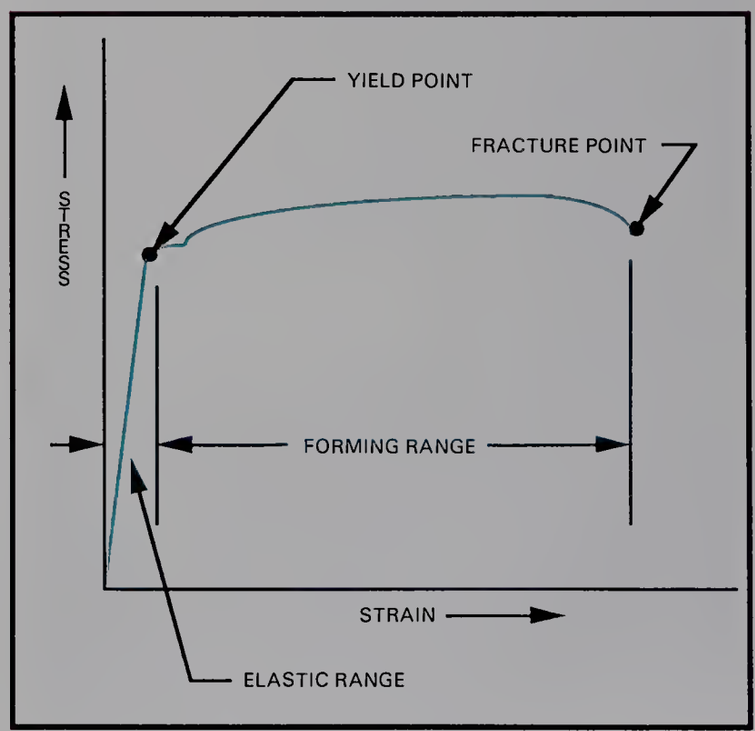


Fig. 5-10. This diagram illustrates the concept of stress-strain.

deform the material only when the force is present. The material will return to its original size and shape when the force is removed. The range of forces, which will temporarily deform a part, is within the material's *elastic range*. However, at one point, the material permanently deforms. This point is called the *yield point*. The material yields to the force and takes on a new shape. There are a range of pressures above the yield point that will permanently deform the material. At some point, the material can stand no more additional force and will break. This point is called the *fracture point*.

The range between the yield point and the fracture point is where forming processes operate. Separating processes always operate above the fracture point. Springs, automobile tires, and elastomer adhesives, for instance, operate below the yield point and in the elastic range.

Hardness is the last mechanical property we will explore. It is a material's ability to resist denting or scratching. Hardness and wear resistance are closely related. Hard materials resist wear better than softer materials. However, harder materials are more brittle. Therefore, a balance between hardness and strength must be maintained. Sometimes, hard surfaces are developed on the material (case hardening). The core remains softer and more ductile. This process, which will be discussed in Chapter 10, offers the "best of both worlds." The surface has high wear resistance, and the inside absorbs stress.

There are a number of ways to test mechanical properties. Common to all these techniques is applying force to a specimen. The specimen is a carefully prepared sample of the material.

Often, a *universal tester* is used. The machine, as shown in Fig. 5-11, can apply tension, compression, or shear forces. The actual test specimen preparation and test procedures is established by the American Society for Testing and Materials (ASTM).

CHEMICAL PROPERTIES

All engineering materials will enter into reactions with one or more chemicals. These reactions are controlled by **chemical properties**. For example, the natural elements in the air (oxygen, nitrogen, carbon dioxide, etc.) may react with a material. Often, the action is called *corrosion*. Iron rusts, copper tarnishes, and aluminum turns dull. In all these cases, a chemical action has taken place. A metallic oxide forms as oxygen joins the pure metal in the material. This action may be unwanted. For instance, we seldom want steel to rust.

Often, materials can be made to resist certain chemicals. For instance, wood can be treated to resist the weather. Plastic and metal food containers can be produced that will not react to the acids in foods. Washing machines can be produced so that surfaces will not be harmed by water, detergents, and bleach.

In many cases, chemical reactions can have advantages. For example, aluminum is anodized to form a protective coating of aluminum oxide. Chemicals are used in a fairly new metal separating process called *chemical machining*. Glass is etched to make it translucent or to decorate its surfaces. All of these actions are based on the chemical properties of materials. These chemical properties determine the reactions of materials and describe the end results of the reactions.

Many industries are vitally interested in the chemical properties of materials. These industries include the pharmaceutical, plastics, and petroleum industries, Fig. 5-12.

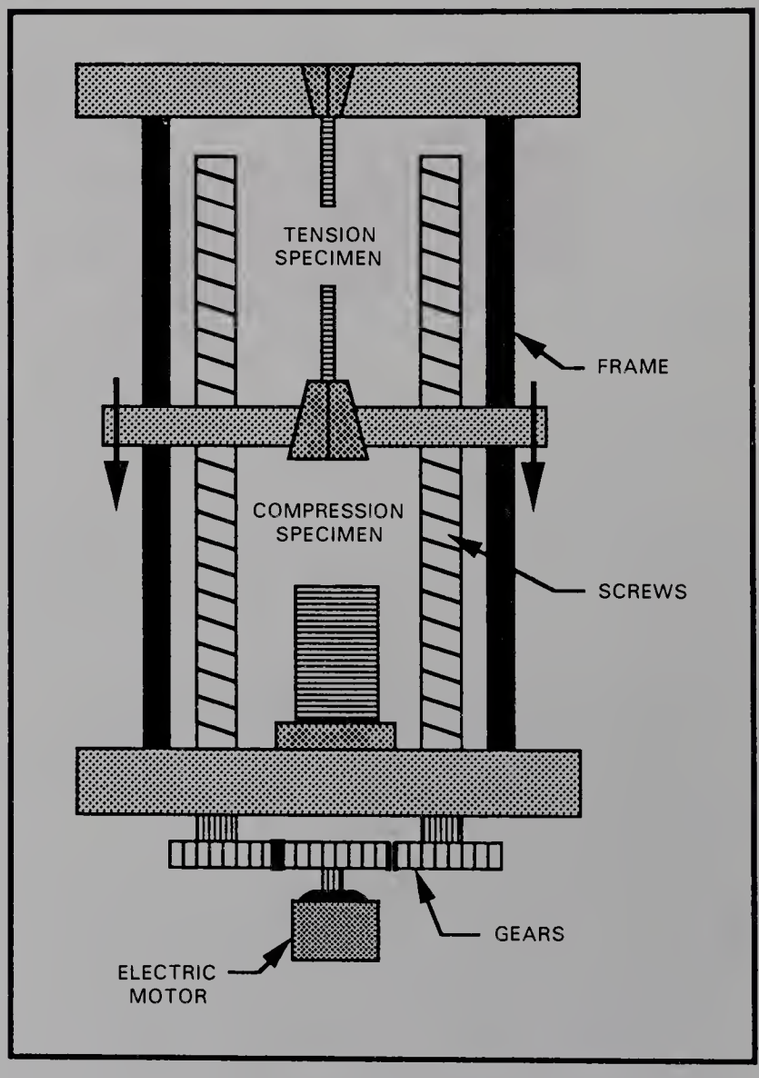


Fig. 5-11. This is a schematic of a common universal testing machine.

THERMAL PROPERTIES

All materials operate in the presence of heat. You may talk about how cold it is in the winter, but you are really talking about less heat being present.

The reactions of materials to varying levels of heat are called their **thermal properties**. These properties include:

- **Thermal conductivity:** This is the ability to conduct heat through the material.
- **Thermal resistance:** This is the ability to resist melting.
- **Thermal expansion:** This is the degree the material expands in the presence of heat (and contracts as heat is removed).
- **Thermal emission:** This is the ability to give off or radiate heat.
- **Thermal shock resistance:** This is the ability to withstand the shock produced by rapid changes in temperature.

Each material has its own assortment of thermal properties, Fig. 5-13. Ceramic materials, generally, have high resistance to heat and melt at very high temperatures. This is the reason ceramic materials are used for baking ware. However, many ceramics suffer from mechanical and thermal shock. Dropping a glass pie plate or putting a hot glass dish in cold water usually results in cracking or breakage.



Fig. 5-12. This scientist is testing the chemical properties of an industrial material. (Xerox Corp.)

Most metals have high melting points. However, they lose their strength and oxidize easily at high temperatures. For instance, a screwdriver is very strong at room temperature. However, if it is heated until it glows red, it will easily bend.

Also, most metals transmit and emit heat readily. Therefore, some metals make good materials for cookware. Metal cookware does, however, require plastic or wooden handles. Metal handles would be too hot to hold. The wood and plastic are thermal insulators.

ELECTRICAL AND MAGNETIC PROPERTIES

Electrical and magnetic properties are important in many applications. **Electrical properties** determine a material's ability to carry an electrical current. One major electrical property is *electrical resistance*. This is the level of resistance the material has to electric current (moving electrons). Sometimes the same property is viewed from the opposite perspective and called *electrical conductivity*.

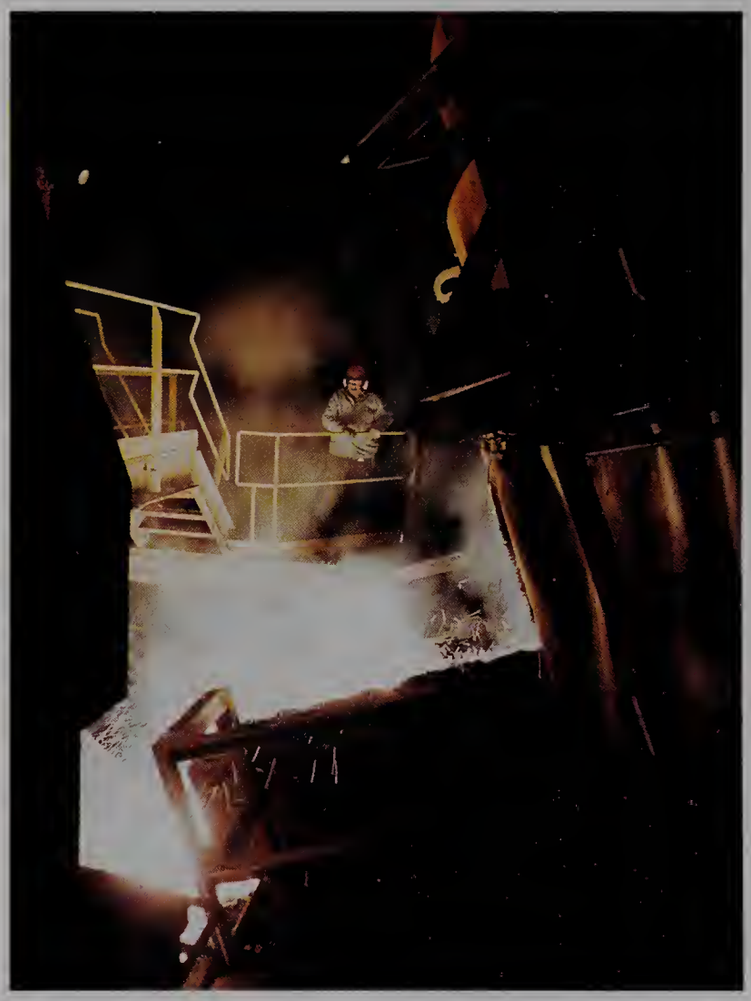


Fig. 5-13. This electric-arc steelmaking furnace is lined with fire brick. These ceramic bricks are chemically inactive and good thermal insulators. (American Iron and Steel Institute).

Engineering materials can be divided in three groups according to their ability to carry an electric current. The major groups are:

- Conductors.
- Semiconductors.
- Resistors.

Electrical **conductors** are metals with low electrical resistance. This property suggests that the material will carry the current with little heat loss. **Resistors** or insulators have a high resistance to electrical current. **Semiconductors** fall into a range between insulators and conductors.

Closely related to electrical properties are **magnetic properties**. This set of properties governs a material's reaction to a magnetic field. **Magnetic permeability** measures a material's ability to become magnetized. High permeability means the material can be easily magnetized when brought into a magnetic field.

A material's **magnetic conductivity** tells you how well magnetic lines of force are conducted through the material. This property can be used to check products for defects. Magnetic waves (magnetic flux) move in a specific pattern in a material. Internal defects (cracks and impurities) cause the magnetic waves to move differently. Therefore, by plotting the magnetic flux, defects can be located, Fig. 5-14.

ACOUSTICAL PROPERTIES

Acoustical properties tell you how a material reacts to sound waves, Fig. 5-15. The two major acoustical properties are acoustical transmission and acoustical reflection. **Acoustical transmission** describes how well sound travels through materials. The reverse of transmission is insulation. The walls of radio and television studios must have low acoustical transmission. Otherwise, the sounds outside the area would be picked up by the microphones.

Acoustical reflectivity determines the amount of sound that will bounce off a material. The materials in a theater or a concert hall should have low sound reflectivity. This keep echoes out of the hall and improves the acoustics. Have you ever gone to a concert in a gymnasium? How were the acoustics? Probably not very good because of all the hard (sound-reflecting) materials in the building.

OPTICAL PROPERTIES

Optical properties determine how a material reacts to light. There are three general optical properties:

- Color.
- Light transmission.
- Light reflection.



Fig. 5-14. This worker is using magnetic inspection to test the quality of a weld and to locate heat-affected zones in a large pipe. (American Cast Iron Pipe Co.)



Fig. 5-15. Rooms in homes should have low sound transmission and reflectivity. Wallpapers, carpets, and draperies reduce the noise level in rooms. (Georgia-Pacific Corp.)



Fig. 5-16. This large greenhouse is used to raise seedling trees. The covering must let light pass through to stimulate the growth of the trees. (Weyerhaeuser Timber Co.)

The color of a material is determined by the portions of the light spectrum that are absorbed and those that are reflected. **Light reflection** tells you how much light is reflected by a material. For instance, a mirror should have a high level of reflection, while window glass should reflect little light.

Light transmission is almost the opposite of reflection. It determines the amount of light that passes through a material. *Transparent* materials allow most of the light to pass through, Fig. 5-16. *Opaque* materials reflect or absorb most of the light energy. *Translucent* materials allow some light to pass through. However, you cannot see objects clearly through translucent materials.

SUMMARY

All materials have a series of properties. These properties tell you how a material will act under certain conditions. The seven major types of properties are physical, mechanical, chemical, thermal, electrical-magnetic, acoustical, and optical.

Understanding these properties will allow you to select the correct material for each job. This can reduce material waste, speed processing time, and produce a product that will function properly.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

acoustical properties
acoustical reflectivity
acoustical transmission
brittleness
chemical properties
compression strength
conductors
density
ductility
elasticity
electrical properties
hardness
light reflection
light transmission
magnetic conductivity
magnetic permeability
magnetic properties
mechanical properties
moisture content
optical properties
physical properties
plasticity
porosity
properties
resistors
semiconductors
shear strength
strength
surface texture
tensile strength
thermal conductivity
thermal emission
thermal expansion
thermal properties
thermal resistance
thermal shock resistance
torsion strength

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. What is the greatest challenge of material selection?
2. Identify and describe the seven major types of properties.
3. Name six major types of physical properties.
4. Which of the following describes a material's ability to undergo compression or stretching without permanent deformation?
   a. Ductility.
   b. Brittleness.
   c. Elasticity.
   d. None of the above.
5. True or False? All engineering materials will enter into a reaction with one or more chemicals.

6. Which of the following is a material's ability to give off or radiate heat?
   a. Thermal shock resistance.
   b. Thermal emission.
   c. Thermal conductivity.
   d. Thermal expansion.
7. True or False? Electrical conductors have a high resistance to electrical current.
8. Magnetic _____ measures a material's ability to become magnetized, while magnetic _____ of a material tells you how well magnetic lines of force are conducted through the material.
9. What two acoustical properties should be considered in designing a recording booth?
10. If you want a material that will reflect or absorb light energy, you should choose one that is:
    a. Opaque.
    b. Transparent.
    c. Translucent.
    d. None of the above.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Review the plans for the tic-tac-toe board shown in the activities section of Chapter 1. Then:
   a. Draw up a chart like the one in Fig. 5-A.
   b. Research properties of different materials.
   c. List on the chart five materials you think might be used for making each of the parts (base and pegs).
   d. In the right hand column, list the properties that made you select each material.
2. Survey the equipment and tools in the technology education laboratory.
   a. Indicate which materials could be worked with the available tools and equipment.
   b. Suggest a set of procedures to be used with one of the materials.
3. Take a 1/4" cross-section of a green wood limb. See Fig. 5-B. Weigh it. Then, following directions from your instructor, place the cross-section in a kiln for 24 hours. Weigh it again. Using the formula in the Physical Properties section of this chapter, determine the moisture content of the wood.

PART	MATERIAL	PROPERTIES
Base:	1.	
	2.	
	3.	
	4.	
	5.	
Pegs:	1.	
	2.	
	3.	
	4.	
	5.	

Fig. 5-A. On a separate sheet of paper, prepare a form similar to this one on which to record your responses.

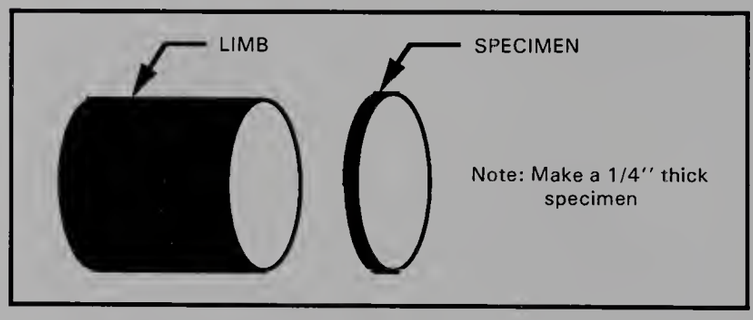


Fig. 5-B. Obtain a cross-section of a green wood limb.



New paints are tested to determine their chemical properties.



MODOIL CORP.



M/A-COM, INC.



GILLETTE CO.



HUCK MANUFACTURING, A SUBSIDIARY OF FEDERAL-MOGUL

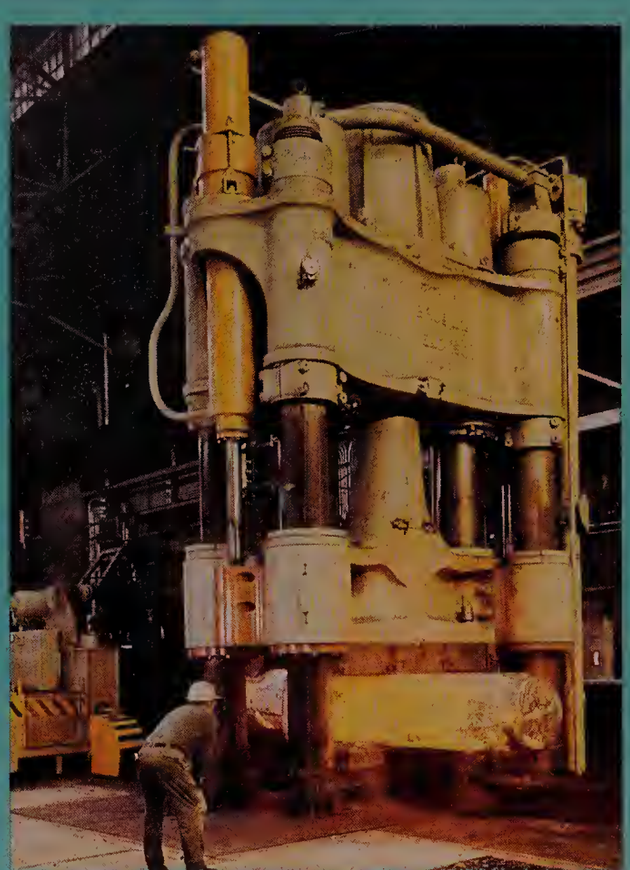
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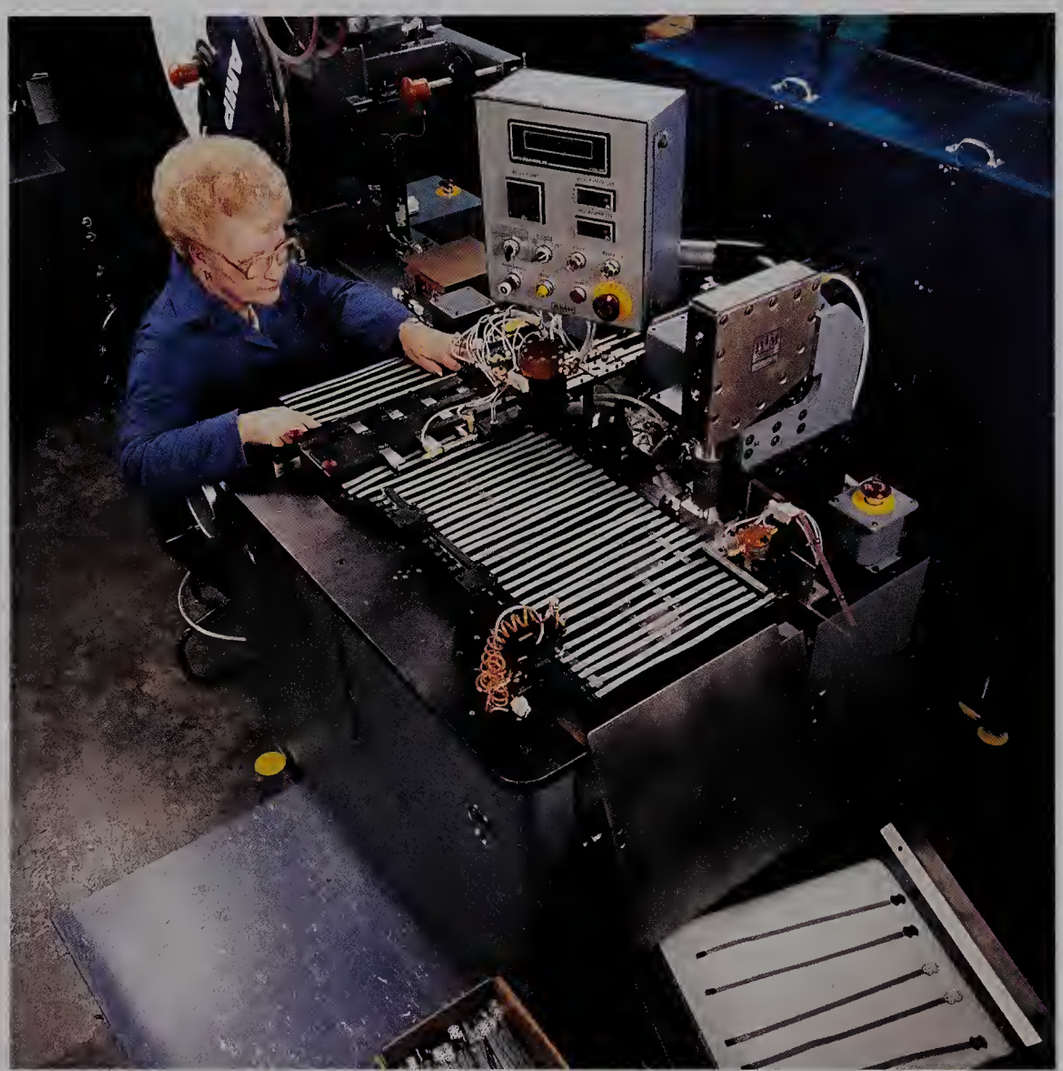
Manufacturing Processes

6. Manufacturing Processes
7. Casting and Molding Processes
8. Forming Processes
9. Separating Processes
10. Conditioning Processes
11. Assembling Processes
12. Finishing Processes

Note: Product ideas and operation process charts pertaining to these chapters follow Chapter 12.







Skilled technicians are needed to perform many manufacturing processes. (AMP)

6

CHAPTER

MANUFACTURING PROCESSES

After studying this chapter, you will be able to:

- *Briefly describe how manufacturing processes have evolved throughout history.*
- *Describe the roles of primary processing and secondary processing in manufacturing.*
- *List and describe the six types or families of processes in producing parts, subassemblies, or final assemblies.*

People have been changing the shape, size, or looks of materials throughout history. They have done this to meet their needs. The ability to transform materials into useful items is a measure of the civilization humans have achieved during various periods of history. The better a society could process materials, the higher the standard of living the people enjoyed.

As manufacturing evolved, complex manufacturing systems emerged. This chapter will discuss past manufacturing achievements and how primary processing and secondary processes function today.

THE EVOLUTION OF MANUFACTURING

The importance of material processing is confirmed by the names given to certain stages of history. Three major eras of human history carry the names of materials–the Stone Age, the Bronze Age, and the Iron Age. These materials dominated tool and product development over long periods of history.

Manufacturing in early civilizations was limited to the work people could perform using the strength in their hands and arms. Later, people found they could increase their abilities to shape materials by using crude tools made of stones or bones. Heavy objects were used to hammer materials into shape and to grind grain for food. This earliest known stage of human culture is called the *Stone Age*.

As time passed, the tools humans used began to evolve. About 5000 years ago, metal tools came into general use. The first metal tools were made from either copper or bronze (an alloy of copper and tin). These tools ushered in the *Bronze Age*. During this stage of human history, the practice of casting copper and working bronze became highly developed. Also, the ability to produce high-quality pottery was developed.

As civilization progressed, so did people's ability to work with new materials. During the time of the Roman Empire, iron slowly replaced bronze as the basic material for tools. This progression moved human civilization into the *Iron Age* starting about 3000 years ago. Iron working skills and wrought iron tools became common.

Throughout the Bronze and Iron Ages, the main techniques used to shape and size materials were human-centered. People provided most of the energy and skill needed to process materials into products.

After the Dark Ages of European history, a major change took place. It started in Europe less than 200 years ago and moved to North America in the middle 1800s. Machines started replacing skilled artisans. This era became known as the *industrial revolution*. Workers began working in central locations called factories. The task of making products was divided into parts. Each worker completed only a portion of the total task. Managers were employed to organize and supervise the production of products. The industrial revolution totally changed how products were made. People also enjoyed a higher standard of living.

Today, products are produced using very complex manufacturing systems. However, these systems have two basic parts or steps that can be isolated and investigated. They are primary processing and secondary processing.

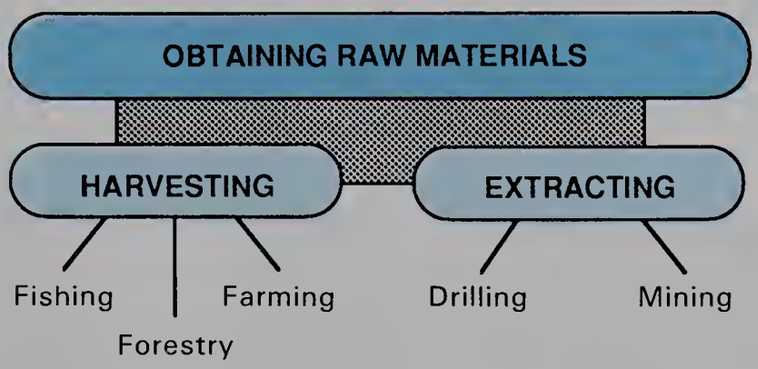


Fig. 6-1. Raw materials are obtained from the earth or oceans through harvesting or extracting. These are some of the activities of primary processing.

PRIMARY PROCESSING

All products can be traced back to natural materials. Look around. You should be able to see products made from trees, iron ore, bauxite (aluminum ore), natural gas (plastics), clay, and sand (glass).

The first series of steps in making a product from natural resources is called primary processing. The raw material must be located and recovered from the earth or oceans. The material is obtained by harvesting or extracting, Fig. 6-1. Trees and farm crops are seeded, grow to maturity, and are harvested. Fish reproduce, grow, and are caught. Likewise, minerals and liquids are located within the earth or under the sea. They are extracted through digging (mining) or drilling.

Once a resource is obtained, it is transported to a primary processing mill like those shown in Fig. 6-2. Here, the material is changed into industrial stock



Fig. 6-2. Raw materials are converted to standard stock at primary processing mills. A–Coal is converted into coke that will be used to make steel. (American Iron and Steel Institute) B–Forest product plants convert trees into lumber, plywood, particleboard, or hardboard. (Weyerhaeuser Co.) C–Aluminum plants produce sheets of aluminum that are used in items such as cans and foil. (Alcan Aluminum Co.) D–Steel mills turn iron ore, limestone, and coke into pig iron that is then made into steel sheets, slabs, bars, rods, and structural shapes. (American Iron and Steel Institute)

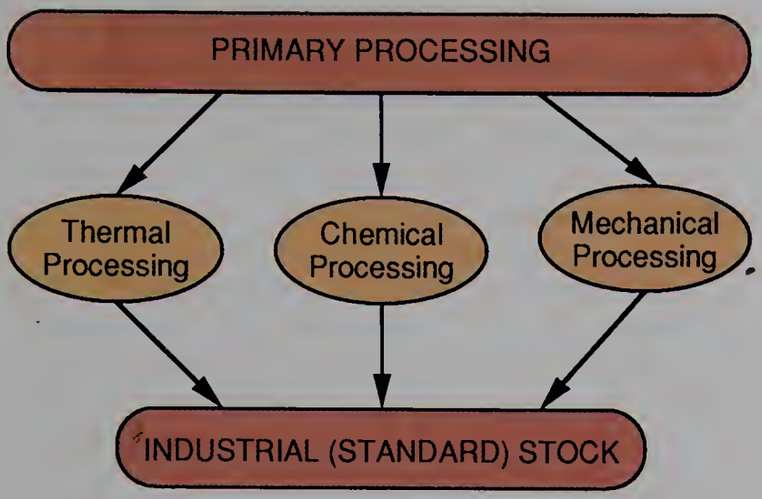


Fig. 6-3. Primary processing uses thermal (heat), mechanical, and chemical means to convert raw materials into industrial stock.

using heat, mechanical processes (cutting, crushing, etc.), or chemical action, Fig. 6-3.

The desired output of primary processing mills is called industrial or standard stock. They are the products of primary processing. Further processing is usually required before the material can serve a final, useful need. For example, lumber must be cut, shaped, and assembled before it becomes a chair on which you can sit. Plastic resin must be heated and molded before you can use it as a drinking cup. Steel must be cut, shaped, and assembled before it becomes a bicycle.

SECONDARY PROCESSING

The act of changing industrial materials into finished products is called secondary processing. Fig. 6-4 shows how primary and secondary processes are related. The output of primary processing activities forms inputs for secondary processing.

Primary processing mills generally are named after the industrial material they produce. For example, you probably have seen, heard of, or read about steel mills, lumber mills, and aluminum mills. These are examples of the many types of primary processing plants. Secondary processing factories are generally named after the finished product they produce. Typical secondary processing plants are automobile plants, dinnerware factories, tire factories, or furniture factories.

Secondary processing factories use six types or families of processes in producing parts, subassemblies, or final assemblies (products). The arrows in Fig. 6-5 show some of the avenues a material may travel. The best processing path is selected in terms of speed, economics, material characteristics, and quality considerations. These processes are:

- Casting and molding.
- Forming.
- Separating.
- Conditioning.
- Assembling.
- Finishing.

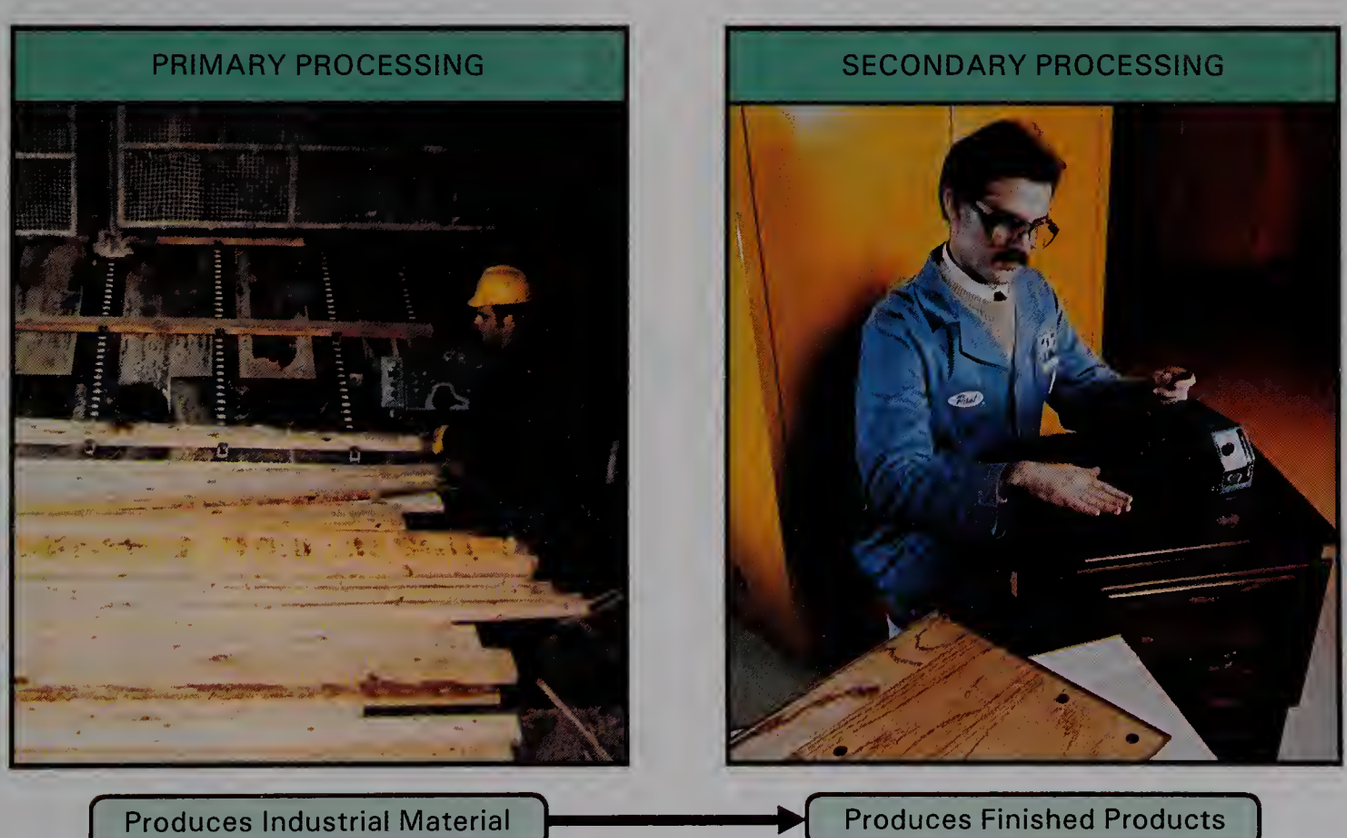


Fig. 6-4. The boards on the left are being produced in a primary processing mill. (Weyerhaeuser Co.) They may become a part of furniture that is a product of secondary processing actions. (PPG Industries)

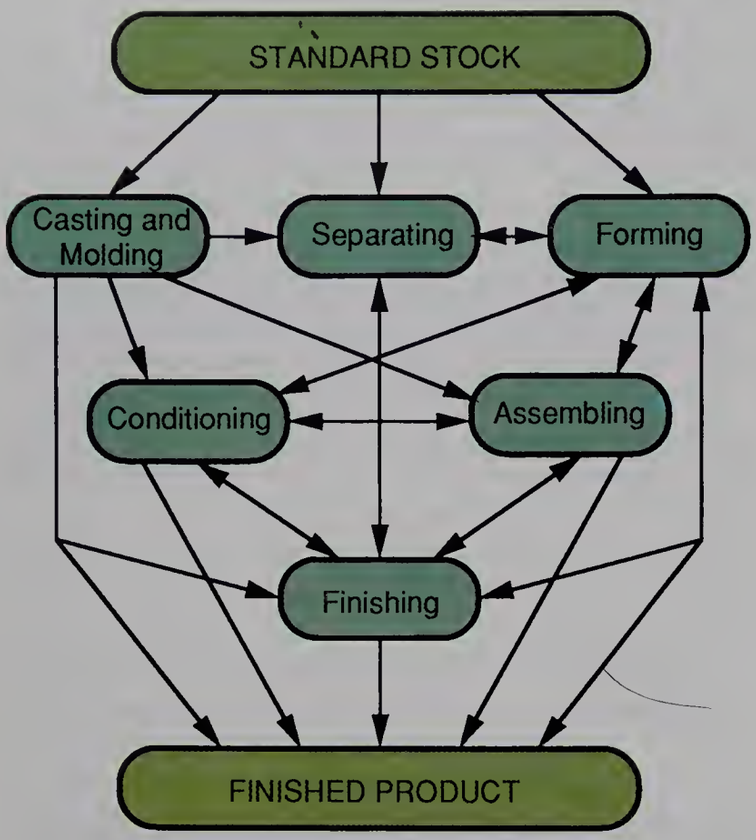


Fig. 6-5. Industrial materials or standard stock are made into finished products using secondary processes.

The first three types of processes size (change the dimension) and shape (change the contour) the material. These processes are usually done first. The last three change the properties of materials and complete the product.

CASTING AND MOLDING

Most metals, ceramics, and plastics can be shaped and sized using a family of processes called **casting** and **molding**. These processes, as shown in Fig. 6-6, follow the same basic procedure. The material is first made into a liquid. It is then poured or forced into a cavity in a mold. There, the material is allowed or caused to solidify (become a solid). The finished, shaped material is removed from the mold. Casting and molding processes reshape the material, but its weight remains constant.

FORMING

Many materials can be given size and shape through a group of processes called **forming**. All of these processes use pressure and a shaped form (die, mold, roll), Fig. 6-7. In forming, the material is placed in a die or fed between a set of rolls. The dies are closed or the rolls are turned. This action applies force to the material and causes it to flow into a new shape. In all forming processes, the weight of the material is unchanged. Only its size and shape are changed. Almost all metals, plastics, and ceramics can be formed.

SEPARATING

A third group of processes, which gives materials new size and shape, is called **separating**. As shown in Fig. 6-8, these processes produce the desired form by removing excess material. Unneeded stock is cut or sheared away. The surplus material becomes **scrap** (reusable) or **waste** (not usable). Separating processes, which remove material in the form of chips, are often called **machining operations.** Almost any material can be separated.

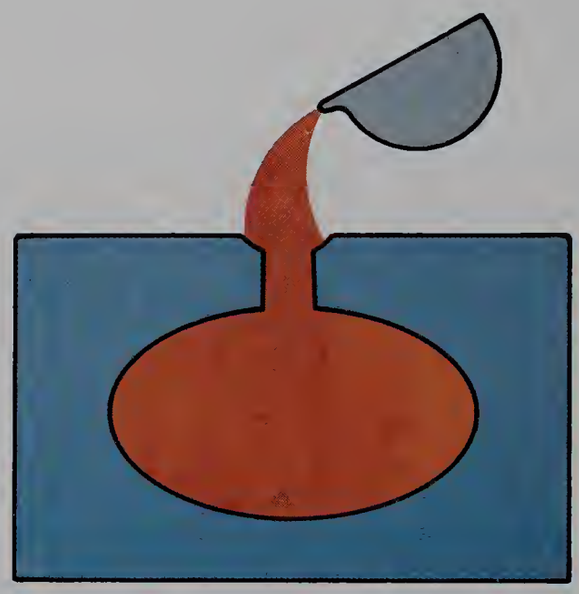


Fig. 6-6. Pouring liquid material into a mold cavity is called casting or molding.

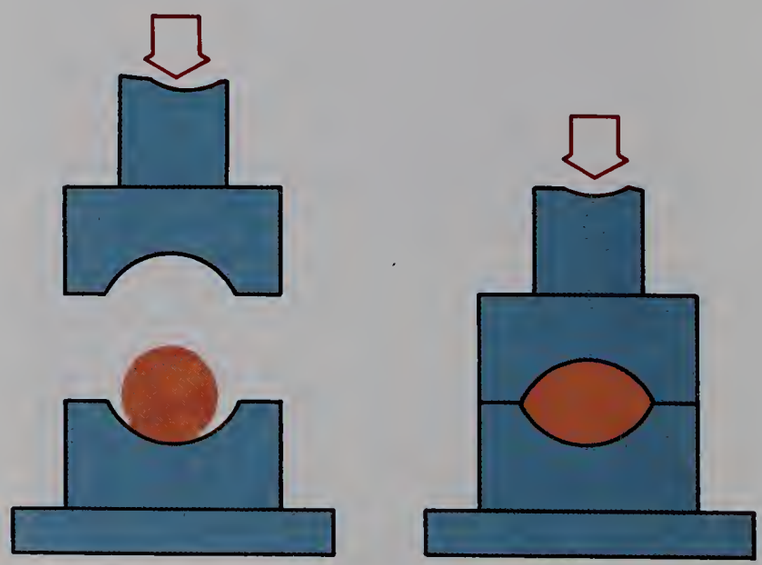


Fig. 6-7. Shaping and sizing materials using pressure and a shaping device is called forming.

CONDITIONING

As you learned in Chapter 5, the properties of a material determine its ability to perform a task. Specific material properties are related to its internal structure. Often, the structure, and therefore the properties, can be changed. The material can be made harder, softer, or more ductile (easy to shape). These changes may be brought about by heat, pressure, or chemicals. Processes that are developed to change the internal structure of materials are called **conditioning** processes.

ASSEMBLING

Few products are made from one part. Generally a number of parts are put together to create the finished product. Creating products from parts, as shown in Fig. 6-9, is called **assembling**. The parts may be permanently bonded through welding or other processes. They may also be fastened mechanically through use of screws or bolts, for example.

Often, several parts are put together to make a segment of a still larger product. This portion of the final product is called a **subassembly**. Putting all the parts and subassemblies together, creates a **final assembly** or product.

FINISHING

Some materials are not particularly beautiful. They may lack color or gloss. Also, most materials can be attacked by sunlight, water, or chemicals in the air. They require a protective coating not only to add beauty but to extend product life. These coatings are applied by **finishing** processes, Fig. 6-10.

Generally, finishing activities are done after the material is sized and shaped by casting, forming, and separating processes. However, some materials are finished first and then given size and shape.

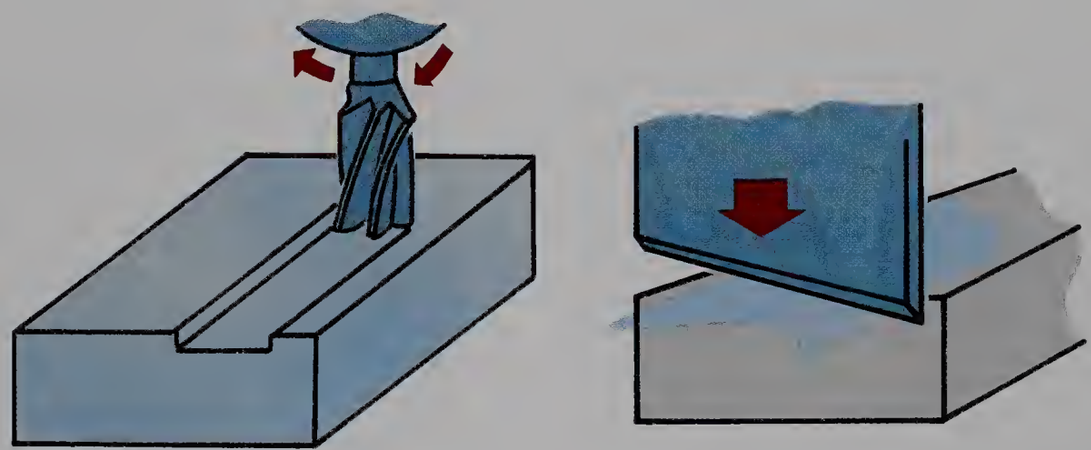


Fig. 6-8. Shaping and sizing materials by machining or shearing excess material away is called separating.

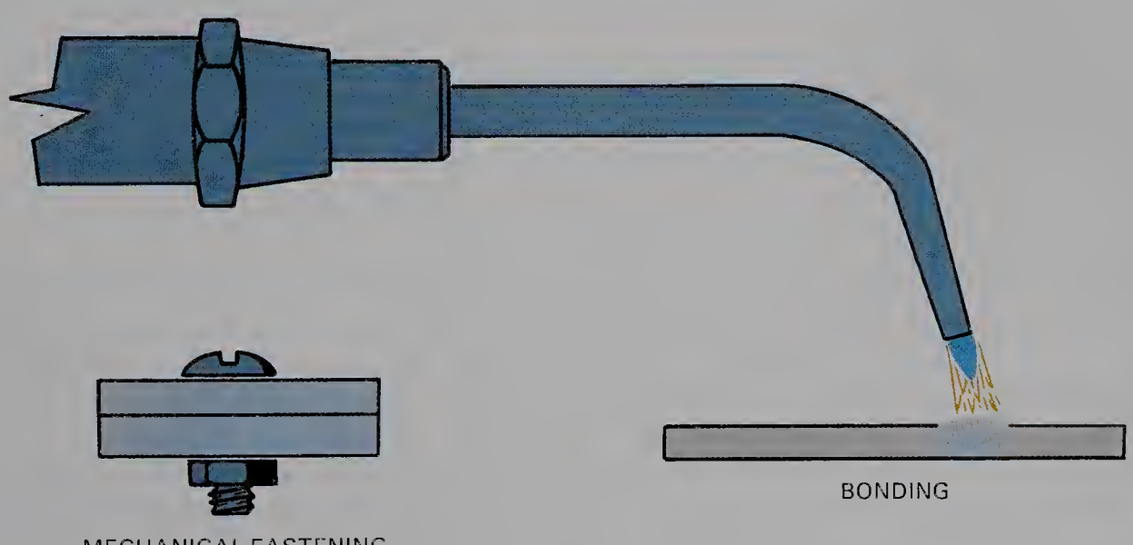


Fig. 6-9. Fastening or bonding parts together to produce a product is called assembling.

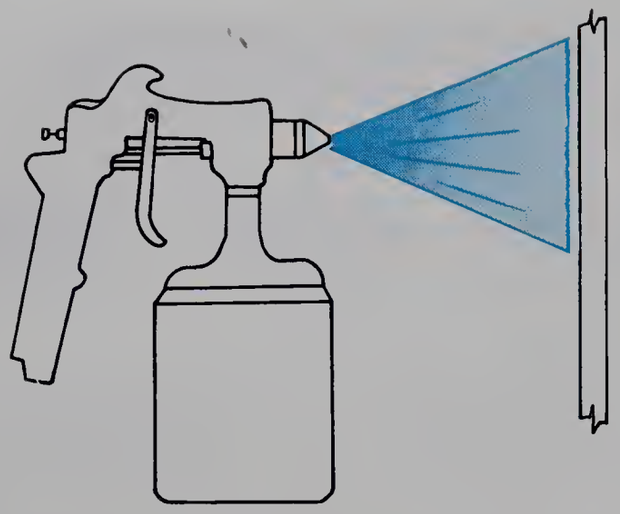


Fig. 6-10. Finishing processes protect and beautify a material. Paint is such a coating.

SUMMARY

Manufacturing has evolved throughout history. Today, products are produced using complex manufacturing systems. Primary processing transforms natural resources into industrial stock. There are thousands of specific secondary processes used to change standard stock into finished products. These processes can be used in almost any order. Secondary processes include: casting and molding, forming, separating, conditioning, assembling, and finishing. The material being processed and the product being manufactured determine the best sequence for the processing actions. The best processing method is selected in terms of speed, economics, material characteristics, and quality considerations. The remaining chapters in this section will explore the families of processes in greater depth. Automating material processing activities will also be introduced toward the end of the book.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

assembling
casting
conditioning
final assembly
finishing
forming
machining operations
molding
scrap
separating
subassembly
waste

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the three major eras of human history that carry the names of materials.
2. During the _____ _____ machines started replacing skilled artisans.
3. During _____ processing, a material is changed into industrial stock using heat, mechanical processes, or chemical action.
4. The _____(output, input) of primary processing activities forms _____(outputs, inputs) for secondary processing.
5. List and describe the six types or families of processes in producing parts, subassemblies, or final assemblies.
6. True or False? During casting and molding processes, the weight of the material is reduced.
7. True or False? Almost all metals, plastics, and ceramics can be formed.
8. During the _____ process, excess material is removed.
9. Processes that are developed to change the internal structure of materials are called _____ processes.
10. Creating products from parts is called:
    a. Finishing.
    b. Assembling.
    c. Casting.
    d. Forming.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Manufacture a simple kite.
    a. Prepare your own design or use the one shown in Fig. 6-A.
    b. Determine procedures and sequence or use those following.
    c. Secure tools and stock.
    d. Cut sticks to length.
    e. Cut slots in the ends of the sticks.
    f. Assemble the sticks into a frame as shown.
    g. Stretch cord around the frame to support the kite covering.
    h. Cut out the covering.
    i. Position the covering over the kite frame. Fold excess material over the frame. Glue or tape the edges.
    j. Attach a saddle string.

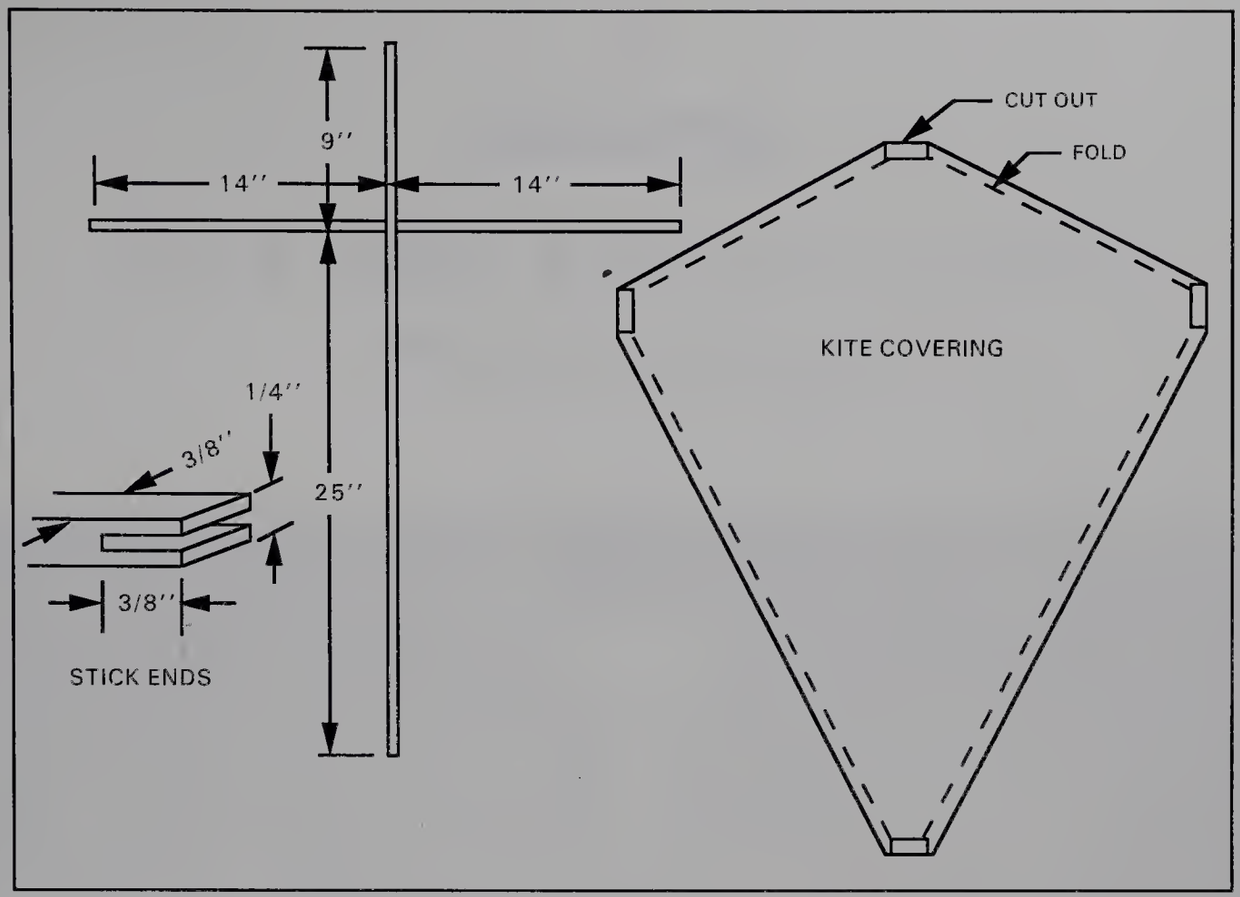
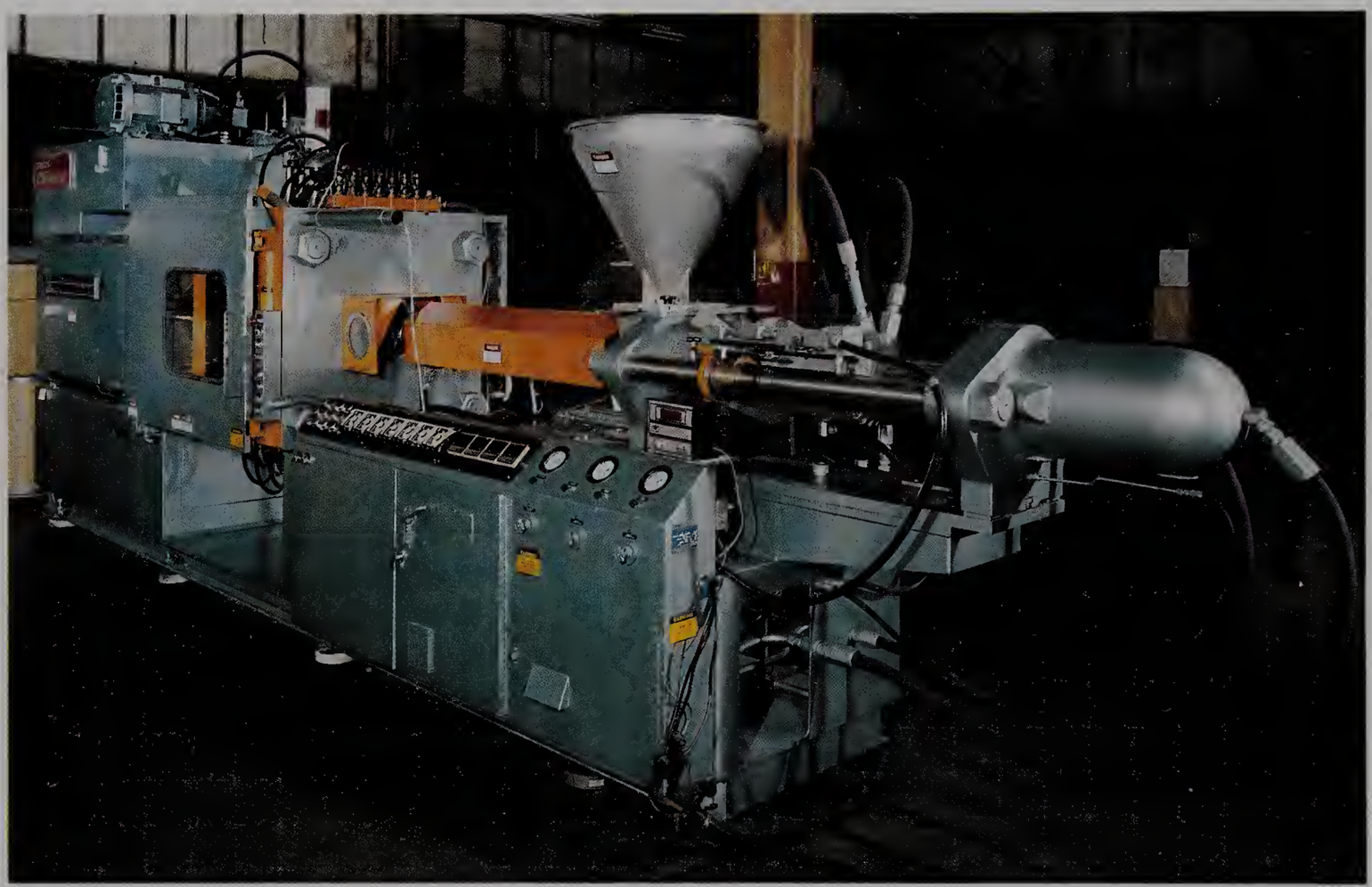


Fig. 6-A. Using these plans, determine the procedure you will use to produce the kite. Note: If using a utility knife or saw, be certain to follow accepted safety procedures when cutting.

2. Prepare a chart like the one shown in Fig. 6-B and use it to describe:
   a. The primary processes used to make the standard stock you used. For example, how were the paper, wood, and string produced?)
   b. The secondary processes used to make the kite. (Use action words like "measure," "saw," and so on.)
3. Select a product you use often and go through all the steps of manufacture as in Activity 1.
   a. Determine your own procedures.
   b. Construct the product.
   c. As in Activity 2, prepare a chart describing primary and secondary processing activities.

Product: ***Kite***	
Primary Processes	**Secondary Processes**

Fig. 6-B. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.



Molding presses, like this one, are often used in plastics molding processes. (Stokes)

7

CHAPTER

CASTING AND MOLDING PROCESSES

After studying this chapter, you will be able to:

- *Explain how casting and molding have evolved.*
- *List the steps involved in casting and molding.*
- *Describe how each step in the casting and molding process is completed.*
- *Give examples of items that result from casting or molding processes.*

Casting and molding, as shown in Fig. 7-1, are a group of manufacturing processes in which the industrial material is made into a liquid. Then it is introduced (poured or forced) into a prepared mold of proper design. The material is allowed to solidify (become hard) before being extracted (removed) from the mold. The finished item is called a casting or a molded part. Casting is the term generally used when working with metal and ceramic materials. The term molding is used when working with plastics.

Casting and molding are the most direct routes from raw material to finished product. This accounts

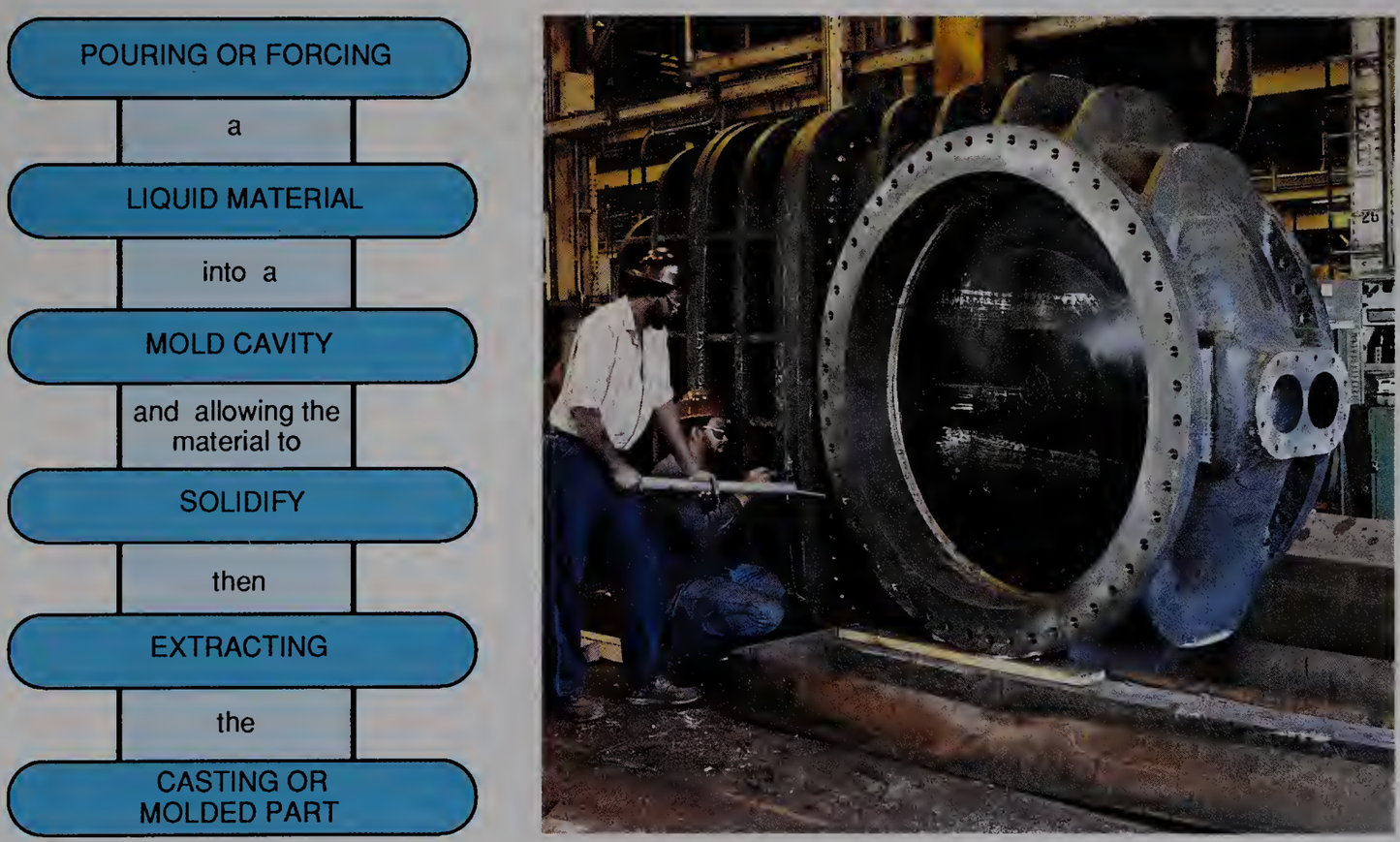


Fig. 7-1. Casting and molding produce a simple or complex shape in a single step. (American Cast Iron Pipe Co.)

for the development of casting and molding early in history.

HOW CASTING AND MOLDING EVOLVED

Casting and molding date back almost 6000 years. Legend suggests that the first metal extracted (separated from the earth) was copper. It is believed that a person banked a cooking fire for the night with rusty-looking rock. As the wood changed into charcoal, the fire became very hot. This heat probably melted copper from the ore (metal bearing rock). When the ashes were scattered the next morning, the first pure metal was discovered. Uses were soon found for this metal. This occurrence propelled humans out of the Stone Age and into the Bronze Age.



Fig. 7-2. Metal was first used for making hand tools and weapons. (Miller Electric Manufacturing Co.)

The first use of this new material was for forged (hammered) tools and weapons. These were shaped using crude methods as shown in Fig. 7-2. Later, metalworkers learned that copper could be formed more easily if it was first heated. During the hot forging process, some of the metal may have become too hot and melted. The melted metal became the standard stock for casting activity.

The art of casting was most likely developed by accident. However, no matter how it was born, casting became the most direct route from raw material to finished part, Fig. 7-3. Casting began to replace the forge and the hammer.

Liquid metal was first poured into molds of sand. Later, molds cut in stone, formed in soft limestone, or pressed out of sunbaked clay were used.

Many developments in casting came from the Orient. The art of casting matured there before it developed in Europe. Before 1000 A.D., the Chinese developed ways of casting iron. Later, the technique of casting crucible steel was invented in India.

Oriental developments in casting technology were brought westward to the Middle East and Europe. Cast bells and cannons became important European products. The first cast iron gun was produced in England in about 1500 A.D.

The first casting in America was done from the famous "Saugus Pot." It was located at the Saugus Iron Works near Boston, Massachusetts. From this lowly start, the modern foundry (metal casting) industry has grown.

STEPS IN CASTING AND MOLDING

Casting and molding processes belong to a single family. Like the members of a human family, there are family similarities and individual differences.

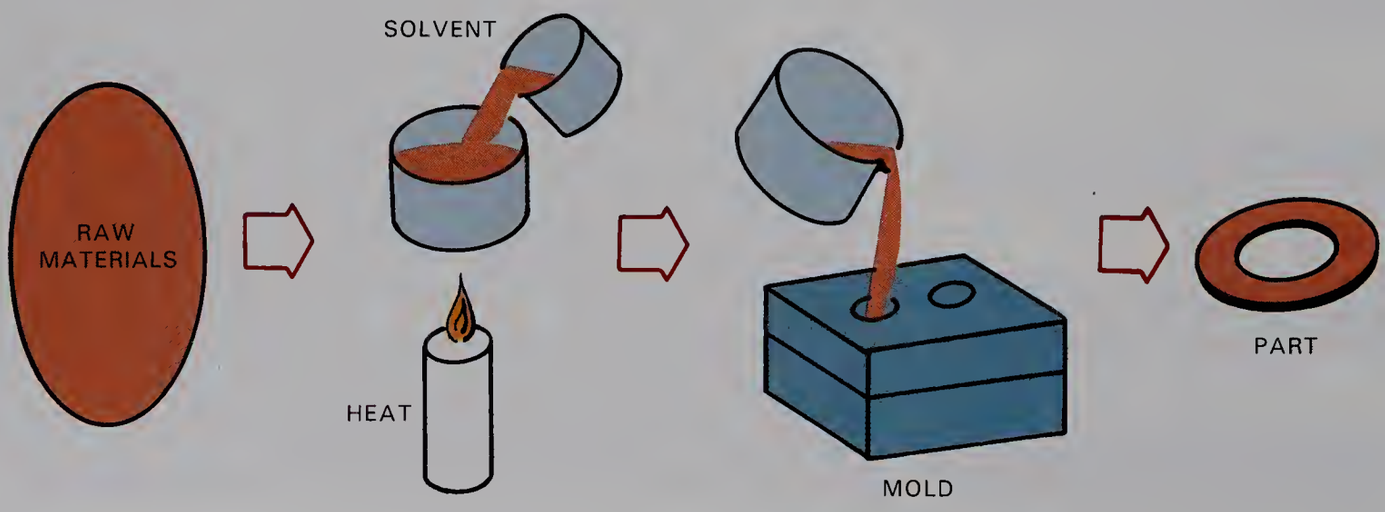


Fig. 7-3. Casting is the most direct route from raw materials to the finished part.

Each casting technique is unique and is used to produce specific products with special characteristics. However, whether the material is clay, metal, plastic, wax, or glass, all casting and molding processes follow the same five steps:

1. A mold of proper design is produced.
2. The material to be cast or molded is prepared (made liquid).
3. The material is poured or forced into the mold cavity.
4. The material is allowed or caused to solidify (harden).
5. The finished casting or molded part is extracted from the mold.

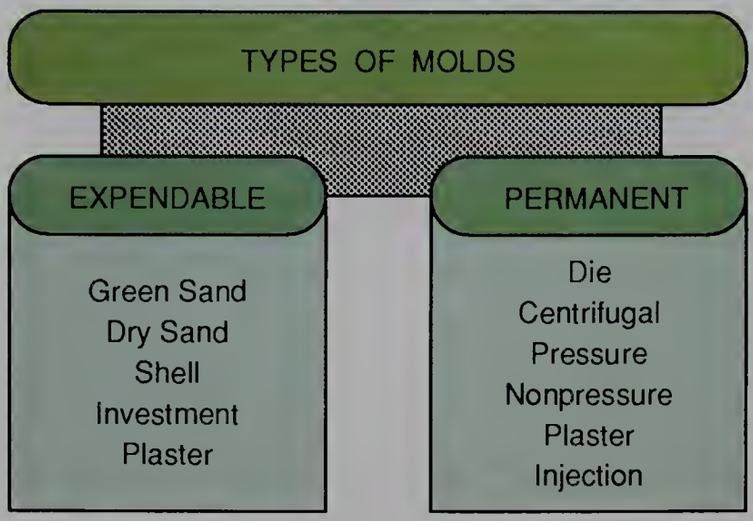


Fig. 7-4. There are several types of molds that can be grouped under two types.

MOLDS

All casting processes need a container to hold the molten material until it becomes hard. This container is called a **mold**. The mold must be constructed with care and accuracy. The **cavity** (shaped hole) inside the mold must make a part of proper size and shape.

Molds for casting and molding fall into two major groups. These, as shown in Fig. 7-4, are:

- Expendable (one-shot) molds.
- Permanent molds.

Expendable molds

Many molds for casting processes are used only once. Removing the finished casting destroys them. These molds, which are called **expendable molds** or one-shot molds, must be easy and inexpensive to produce. The most common expendable mold materials are sand and plaster.

Producing expendable molds follows a two-step process, as shown in Fig. 7-5. First, a **pattern** of proper size is made. A pattern is a shape made from wood, metal or epoxy. This pattern must have **draft** (angled sides) so it can be removed from the mold.

The pattern gives the mold its shape. The mold is generally made in two or more parts. This allows the mold to be separated to remove the pattern. The mold material is poured or packed around the pattern. Then the pattern is removed and the mold is reassembled. It is now ready to receive the molten material.

Green-sand casting molds. Metal casting techniques account for nearly all expendable molds used. The most common of these techniques is green sand casting. Creating these molds follows the steps shown in Fig. 7-6.

The first step is to make a pattern in the exact shape of the finished product. The pattern will be larger than the desired product. This compensates for the

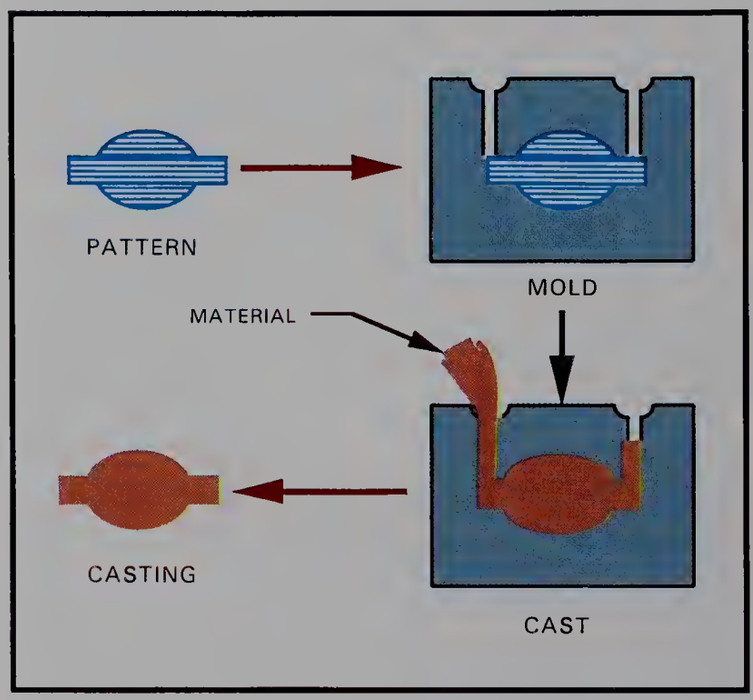


Fig. 7-5. Expendable casting processes involve creating a pattern, making a mold, and producing a casting.

shrinkage that occurs when molten materials cool. The amount the pattern is enlarged depends on the metal being cast. This added size is called the *shrink allowance*.

The mold is made in a rectangular metal box called a *flask*. The flask has two parts: the *cope* (top) and *drag* (bottom). Each half has four sides, but no top or bottom.

The pattern is placed inside the drag, Fig. 7-6A, and rests on a bottom board. It is covered with a thin layer of *parting compound*. This fine powder allows for easy removal of the pattern from the mold.

Sand is *riddled* (sifted through a screen) over the pattern and pressed around it. The drag is then filled

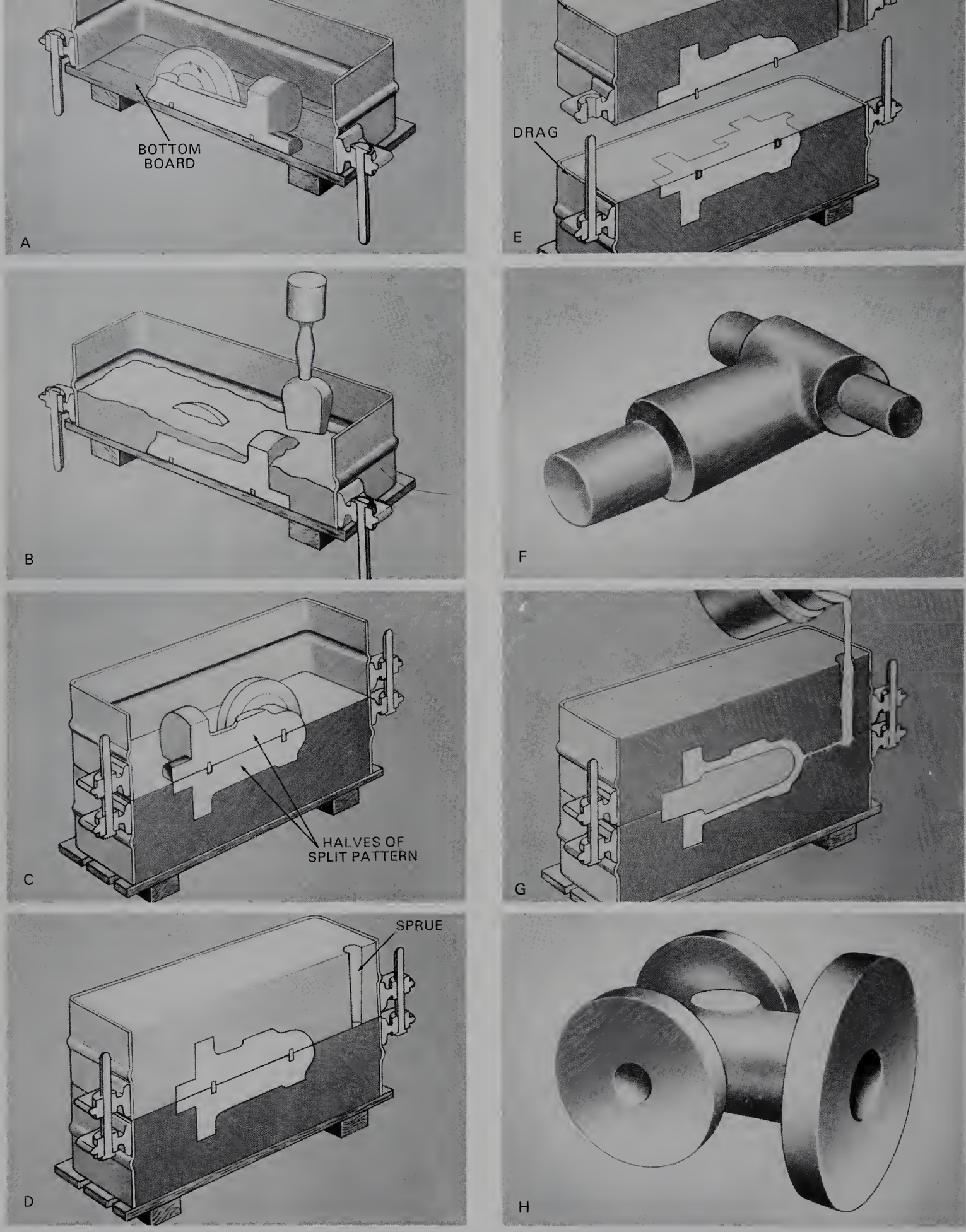


Fig. 7-6. This illustrated cutaway explains the step-by-step procedure used in making a green-sand mold. A–The pattern is placed in the drag and dusted with parting compound. B–Sand is riddled and packed around the pattern. C–The drag is turned over and the cope is assembled on the drag. The second half of the split pattern is positioned properly. D–The cope half of the mold is rammed and gates are cut to allow the metal to flow. E–The flask is separated and the pattern is removed. F–When appropriate, a baked sand core is placed in the cavity. The core will produce holes in the casting. G–The mold is assembled and the metal is introduced into the cavity. H–The finished cavity is removed by vibrating the mold until it falls apart. (Gray and Ductile Iron Founders' Society)

with sand and *rammed* (tamped down), Fig. 7-6B. The excess sand is struck off to provide a smooth top for the mold.

The drag is turned over, and the cope is put in place. If a two-part (split) pattern is used, the second half is placed in the cope, as shown in Fig. 7-6C. Again, parting compound is applied, and the sand is riddled, packed, rammed, and struck off. See Fig. 7-6D.

Next, the cope and drag are separated, Fig. 7-6E. The pattern is carefully removed. This leaves a cavity for the molten metal that is the proper size and shape.

The last step in making a green sand mold involves providing channels or gates for the molten metal to flow into the cavity. The metal will be poured through an opening on one side of the mold called the *sprue*. It will fill the cavity and flow up an opening on the other side. This second channel, which allows gases to escape, is called the *riser*. Fig. 7-6G shows the molten metal being poured into the mold.

There are two other important expendable molds. They are shell molds and plaster molds.

Shell molds. Shell molds were developed during World War II. The technique involves using a hot metal pattern to produce each half of the mold. The pattern is covered with a sand and resin mix. The heat from the pattern melts the resin. This action forms a sand crust (shell) over it. When the shell has reached a proper thickness, it is carefully removed from the pattern and cured in an oven. The two cured mold halves are clamped together.

This makes them ready to receive the molten metal. Shell molds produce a more accurate part than green sand molding. Also, the part has a smoother surface.

Plaster investment molds. Plaster investment molds are one of the oldest types of molds. They were developed in China and Italy. This technique became an important industrial process during World War II. Plaster investment molding starts with a wax pattern. Plaster is poured around the pattern and allowed to harden. When the mold is heated, the wax melts. The liquid wax is poured out leaving a very smooth, accurate mold cavity.

Permanent molds

Some casting processes use a mold that is designed to produce a large number of castings before it must be discarded or repaired. These molds are called **permanent molds**. They are used to cast nonferrous (not iron) metals, plastics, and ceramics.

Permanent molds have cavities machined or otherwise formed into them. The cavities must be produced with the same concern for draft and material shrinkage. In addition, the molds must have a way to insure that the two halves line up with each casting.

Look at Fig. 7-7. It shows a permanent injection mold used to make plastic automotive parts. Notice that this mold, like all others, has a cavity in which the material is shaped. It also has a channel to allow the material to flow into the cavity.

Permanent molds are more expensive to make than expendable molds. However, their ability to withstand the pressures created by forcing materials into them is an advantage. Also, permanent molds generally provide better dimensional control of the part and a smoother surface finish.

PREPARING THE MATERIAL

Material to be cast must become a liquid or semi-liquid. Several methods can be used to change the material to this physical state, Fig. 7-8. These methods are melting, dissolving, and compounding.

Most metals and plastics are **melted** or softened. Some processes use a separate furnace to melt metals.

Other materials, such as clay, can be **dissolved** or suspended in a liquid. The suspended material is called **slip**. The particles in the liquid remain solid, but the liquid carries them into the mold. Bathroom



Fig. 7-7. This is an injection mold that has been opened to release a newly molded plastic automotive body part. The A indicates the mold, while the B points to the molded part. (Guide Lamp Div., General Motors Corp.)

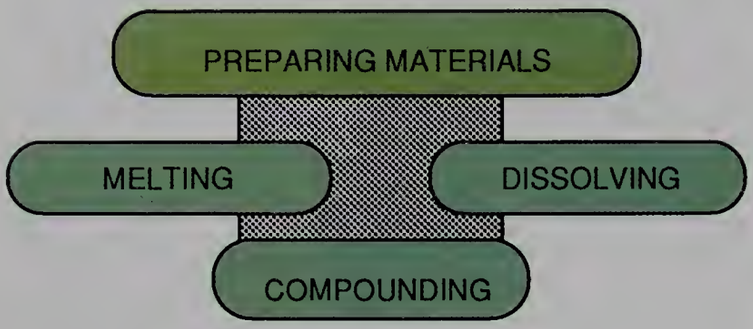


Fig. 7-8. Material may be prepared for casting in three basic ways.

fixtures, ceramic decorative items, and some dinnerware pieces are produced from this type of material.

Still other materials, such as some plastics, are **compounded** (mixed) or manufactured in a liquid form. They can be poured or forced into a mold in the natural state. During preparation, additives may be mixed with the material to be cast. Coloring agents may be added to plastics and clays. A catalyst (material that starts or speeds up a chemical action) may be added to plastics to cause them to harden. Other materials may be added to the original material to change properties. For example, plastic can be made harder, more flexible, stronger, or more durable.

INTRODUCING THE MATERIAL INTO THE MOLD

There are two basic ways of introducing the material into the mold. The material, as shown in Fig. 7-9, may be either poured or forced into the cavity.

Gravity causes the mold to fill with liquid material during pouring, Fig. 7-10. Most expendable molds are filled this way since they cannot withstand much pressure. Poured molds include green-sand and shell molds for metals; slip casting molds for ceramics,

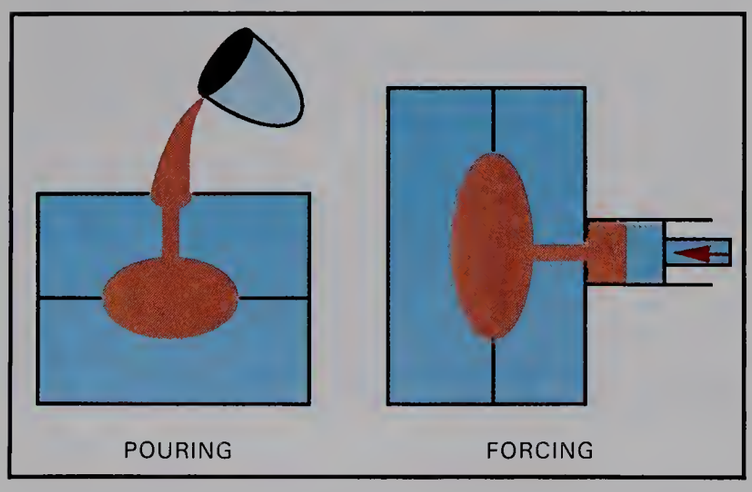


Fig. 7-9. Materials can be introduced into molds by pouring (gravity) or forcing.



Fig. 7-10. Aluminum is being poured from a ladle into a green-sand mold. (Crouse-Hinds Co.)



Fig. 7-11. Top. A worker pours clay into the slip casting molds. When the clay hardens to the desired thickness, extra slip is poured from the mold. Bottom. After the slip has solidified, the sink is removed from the mold. (Kohler Co.)

Fig. 7-11; and nonpressure permanent molds for metals, plastics, and wax.

Some materials are forced into the mold cavity. The two major techniques using force are die casting of nonferrous metals and injection molding of plastics.

In **die casting**, the metal is melted in a "pot." Then a ram (plunger) forces the metal into a permanent, water-cooled steel mold. Here, the material solidifies. The mold opens and the finished part is ejected. Fig. 7-12 shows a typical die casting operation. As with all casting operations, the die cast material goes from raw (industrial) material to a shaped part in one step. The castings require only a minimum amount of machining before they are ready to use. Die cast products include toys and some automotive parts.

Injection molding is very much like die casting. The biggest difference lies in the material being processed. Die casting casts nonferrous metals, while injection molding shapes plastics. Again, the material is heated in the machine. Then a screw or ram forces it into a cavity. The material solidifies and is then ejected. Plastic and many synthetic (human-made) materials can be produced by injection molding, Fig. 7-13. These molded parts include models, toys, game pieces, and other items.

Like die casting, **centrifugal casting** forces molten material into the mold. A spinning action generates



Fig. 7-13. This automobile bumper was molded using the injection molders in the background. (Cincinnati Milacron)

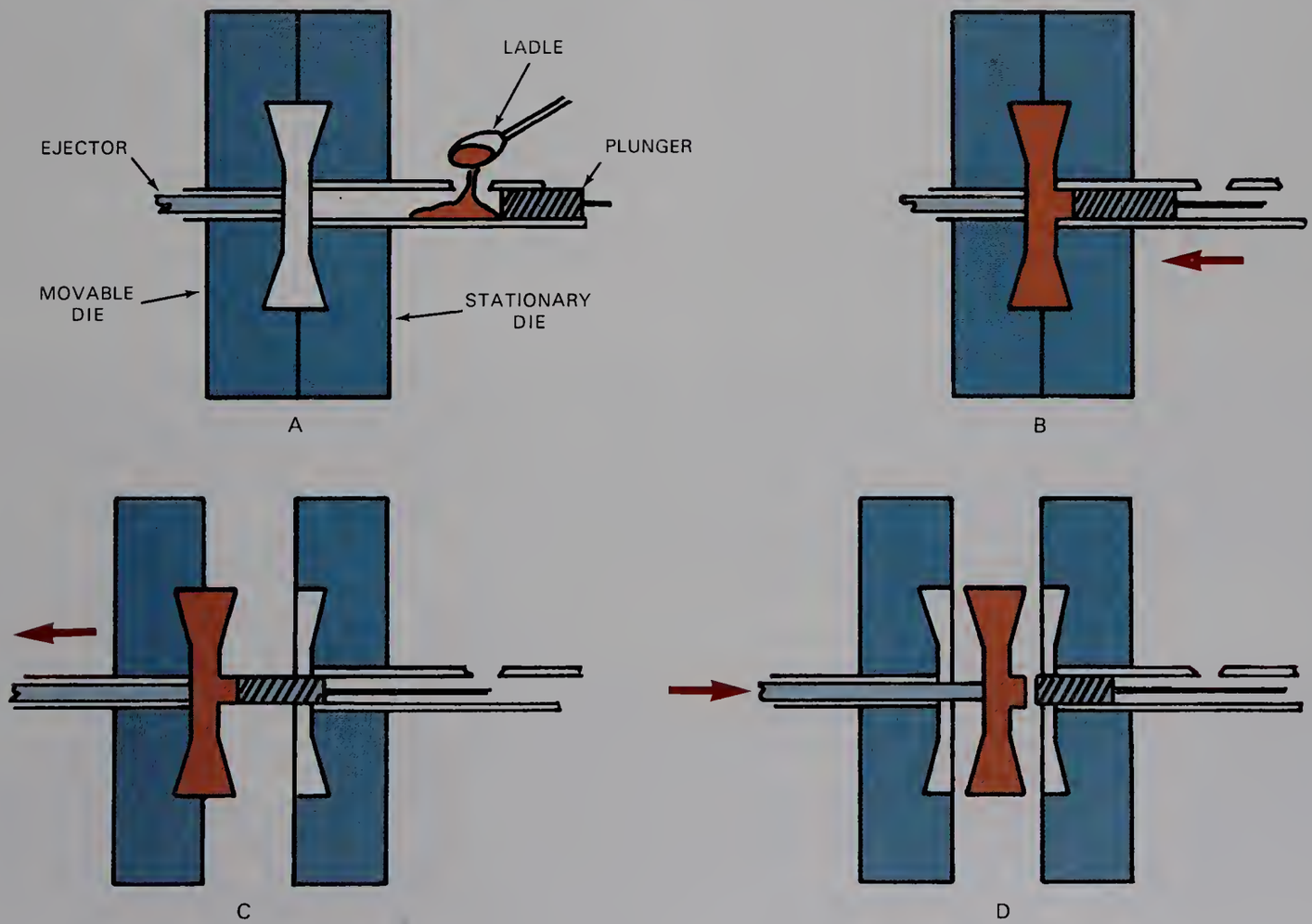


Fig. 7-12. Steps in cold-chamber die casting. A–Metal is placed into the chamber. B–A plunger forces the molten metal into the die. C–The metal solidifies. Then the die opens. D–The finished part is ejected.

the force. This is the same force that "throws" a person against the sides of a spinning carnival ride. In centrifugal casting, the molten metal is placed in the mold. The mold is then spun. This action causes the metal to be thrown to the outside of the revolving mold. A major product of centrifugal casting, as shown in Fig. 7-14, is cast iron pipe.

In **slip casting**, liquid slip (clay suspended in water) is poured into a plaster of paris mold. The plaster mold wall absorbs water from the slip causing it to harden from the outside inward. The clay is allowed to build wall thickness by the drying action. If the product is to be hollow, the liquid material in the middle is poured out leaving the clay shell. Solid casting allows the clay to totally harden, as shown in Fig. 7-15. After a drying time in the mold, the soft clay casting is removed. It is then allowed to dry further before it is processed into a finished product. Ceramic figurines, cream pitchers, and bathroom fixtures are made by this process.

Slush casting can be used to cast hollow metal objects. The molten metal is poured into the mold as in other metal casting processes. However, before the metal hardens, the process is interrupted. As the mold absorbs heat, a solid shell of metal is formed on the mold walls. When the wall thickness is right, the excess metal is poured out of the center of the casting.

Plastic objects can also be shaped using the slush casting technique. However, in this technique, powdered plastic is placed in a heated mold. The heat causes the plastic to fuse, forming a thin shell next to the mold. The longer the plastic is allowed to remain in the mold, the thicker the shell will become. As with metal, the excess plastic is poured out when the wall is thick enough.

SOLIDIFYING METHODS

Once the material has been placed in the mold, it must harden for the product to be usable. This is called **solidifying**. Solidifying can be done using one of three methods:

- Cooling.
- Drying.
- Chemical action.

One way to harden a material is to remove heat. *Cooling* water creates ice. Likewise, removing heat from molten metal or plastic will return the material to its normal solid state.



Fig. 7-15. These cup handles were made in poured (gravity-filled) slip casting molds. Drying caused the material to solidify. (Syracuse China Corp.)

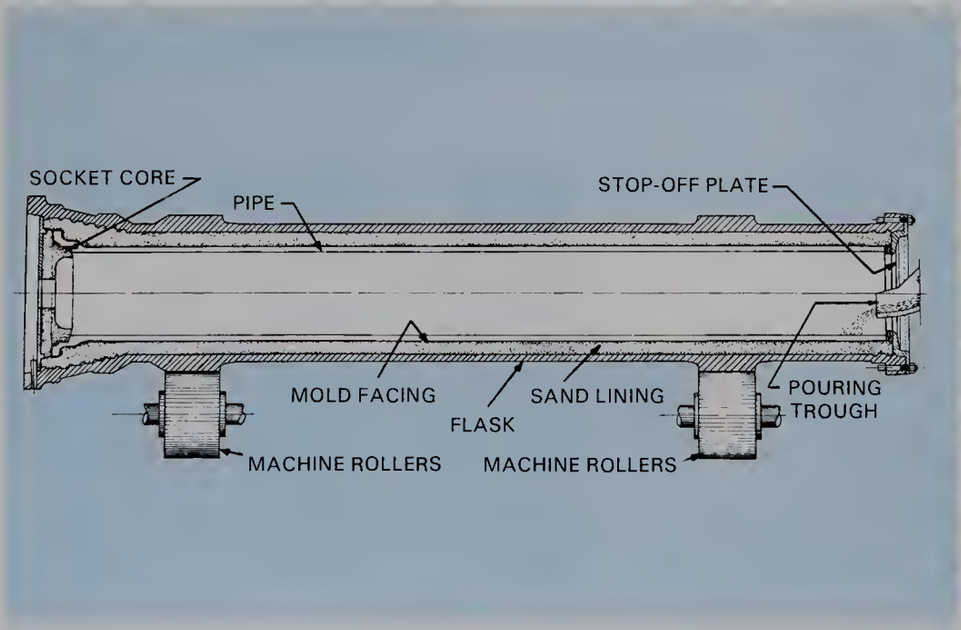




Fig. 7-14. Cast iron and steel pipe, like that shown on the right, can be cast using the centrifugal casting technique diagrammed on the left. (American Cast Iron Pipe Co.)

In the case of melted plastics, melted metals, or other materials, air or water may be used to cool the molten materials. Water may be circulated through channels in a permanent die casting or injection mold. The fluid carries away the heat from the mold and part. The system works like the cooling system of an automobile that removes the combustion heat from an engine. The air in the room may be used to carry away the heat in green-sand casting and shell molding operations. This process is slower, but cheaper, than fluid cooling of permanent molds.

A second method of solidifying materials is *drying*. This method removes solvent from a dissolved or suspended material. Most cast ceramic materials are solidified in this manner. Of all the ceramic casting process that use drying, slip casting is most common.

The third way to harden a material is by *chemical action*. Liquid materials, like plaster of paris, concrete, and casting acrylic (plastic), become hard because of internal action. Their chemical structures are altered, which changes the liquid material into a solid. Adding water may be enough to start the action. Plaster of paris and concrete set (become hard) in this manner. Other materials, like liquid acrylics, harden after a *catalyst* is added. This agent starts the chemical action needed to solidify the material.

Once the chemical action starts, it cannot be stopped. This is why you will see people working concrete rapidly. They have a limited time to smooth and finish the surface before the material becomes too hard to work.

EXTRACTING THE CASTING OR MOLDED ITEM

The **extracting** step involves removing the casting or molded item from the mold. The technique used is determined by the type of mold used.

Expendable molds are broken apart to remove the product. Sand molds are vibrated to cause them to collapse. Plaster and shell molds are fractured to remove the cast or molded part.

Permanent molds open and close easily. Often, the casting or molding machine automatically opens the mold. Then ejector pins push out the finished part. The mold automatically closes, and the casting operation can be repeated.

SUMMARY

You have learned that casting and molding processes provide the most direct route from raw material to shaped part. All these processes use the same five basic steps. First, a permanent or expendable mold is produced. Then, the material is prepared to be introduced into the mold. It may be heated to its melting point, dissolved or suspended in a liquid, or compounded. The molten material is introduced into the mold by gravity or with force. The material is then caused to solidify through cooling, drying, or chemical action. Finally, the finished casting or molded part is removed from the mold. Expendable molds are destroyed to remove the product. Permanent molds are opened, and the part is removed.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

cavity
centrifugal casting
compounded
die casting
die casting
dissolved
draft
expendable molds
extracting
green-sand casting molds
injection molding
melted
mold
pattern
permanent molds
plaster investment molds
shell molds
slip
slip casting
slush casting
solidifying

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Distinguish between casting and molding.
2. List five steps that are common to all casting and molding processes.
3. True or False? Permanent molds, called one-shot molds, are easy and inexpensive to produce.
4. List the three methods of changing materials to a liquid or semi-liquid state.
5. _____ _____ casts nonferrous metals, while _____ _____ shapes plastics.
6. Name three methods of solidifying materials.

7. During the extracting step, the casting or molded item is:
   a. Added to the mold.
   b. Removed from the mold.
   c. Becomes solid in the mold.
   d. None of the above.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Manufacture a part or product using a common casting process.
   a. Before making a selection of a product, be sure that your technology education laboratory has the necessary tools and equipment. Suggestions for your consideration:
      - A candle made in a green-sand mold.
      - A plaster wall decoration using a permanent mold.
      - Plastic screwdriver handle, Fig. 7-A.
   b. Review the casting processes you have studied. Then, prepare a set of procedures for making the product you have chosen.
   c. Review all casting procedures with your instructor.
2. Look around the room. List as many products or parts that you can see that were produced using a casting process. Next to each one, list the process you think was used and determine whether a permanent or expendable mold was used. Present your data on a chart like the one shown in Fig. 7-B.

Product or Part	Process	Mold Used

Fig. 7-B. On a separate sheet of paper, prepare a chart similar to this one on which to record your answers.

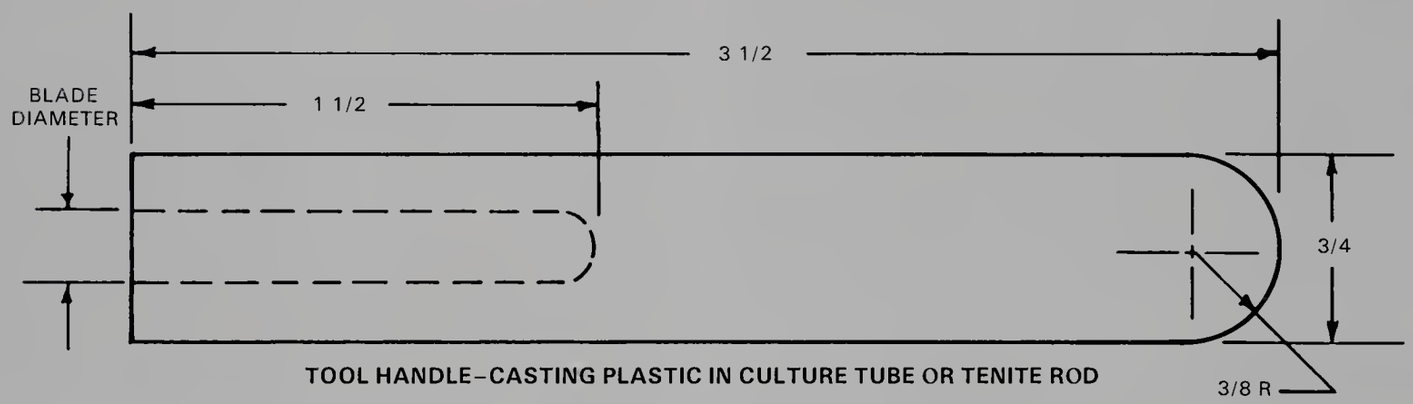


Fig. 7-A. Use these plans to cast a screwdriver handle.

8

CHAPTER

FORMING PROCESSES

After studying this chapter, you will be able to:

- *Explain how forming has developed.*
- *List the three essential elements that must be present in order for forming processes to take place.*
- *Identify various types of shaping devices used in forming processes.*
- *Explain why the temperature of a material is an important consideration in all forming operations.*
- *Name and describe three types of forming forces.*



Fig. 8-1. This hot metal part is being removed from a forging die. (Budd Co.)

Forming changes the size, but not the volume, of a workpiece as it is shaped. This change is made by applying force to the material with a shaping device. In order for forming to take place, the force must be above the yield point of the material and below the fracture point.

The force must be strong enough to make a material take on a new, permanent shape. The lowest point at which force will permanently deform a material is called its **yield point**. However, the force must not make a material crack or break, Fig. 8-1. The point at which this happens is called the **fracture point** of a material.

DEVELOPMENT OF FORMING

Hammering by hand was the first forming method used to shape metals. Since the Bronze Age, about 4000 years ago, humans have melted metals, poured them into molds, and hammered the materials into new shapes. This hammering action is a forming process. Like all forming techniques, it changes the size and shape of the base material. However, it does not involve removing material through cutting or shearing. Rather, the material is simply reshaped with no weight loss.

One of the earliest uses of forming processes was in producing hunting weapons. The development of metal-pointed spears and knives made hunting and food gathering easier. Cutting trees and brush became simpler with the metal ax. Metal knives gave much better results than the stone-edged tools commonly used for cutting food.

Many early military and political conquests were won using weapons formed from solid metal. Solomon, and later, Alexander the Great, depended on

forged weapons to equip their armies. Vast territories were won or lost on the strength of forged metal.

In the New World, formed products were important to early settlers. The village blacksmith was the first colonial forming expert. Using a hammering force on the anvil, the blacksmith produced forged items such as wagon tires, chain, and horseshoes.

Rolling became an important industrial forming process. **Rolling** causes a material to flow into a new shape as a result of an applied force. This process is similar to a cook using a rolling pin to roll out pie crust dough to bring it to the proper thickness.

Paul Revere practiced a third type of forming. He produced his famous silver bowls through a **drawing** process. He carefully stretched and drew silver and pewter sheets into useful shapes with the hand tools of the day. Today, large presses perform the same tasks in a fraction of the time.

ESSENTIALS OF FORMING

Forming includes all manufacturing processes that reshape materials by placing pressure or stress on a solid workpiece. In all forming processes, three essential elements are present or considered. These, as shown in Fig. 8-2, include:

- A shaping device.
- An appropriate material temperature.
- A sufficient forming force.

SHAPING DEVICES

The shaping device for a forming process does the same job that the mold does for casting and molding operations. The **shaping device** determines the final shape of the part or product being produced. Two major types of shaping devices are used in forming processes. These are dies and rolls.

Dies

Dies are common shaping devices used in many forming operations, Fig. 8-3. These devices are blocks of hard steel called *tool steel*. They can be used to form any material that is softer than the die. Commonly, dies are used to form metals and plastics.

Dies can be grouped into three major categories: open, closed, and one-piece shaped dies. See Fig. 8-4.

Open dies. The simplest type is called an **open die**. It consists of two flat die halves. The part forms as a result of force applied between the die parts.

The village blacksmith's anvil and hammer were crude examples of this type. The anvil was a stationary (unmoving) die. The hammer was a moving die that applied force to the work. The hammer striking the work caused the hot metal to take a new shape.

A once common type of open die forming is *smith forging*, Fig. 8-5. In this process, a flat die is fixed to the solid base of a press or hammer. The other die part is attached to a movable plunger. The operator places the heated metal workpiece between the die parts. The hammer or press is then activated. The heavy, upper die part drops or is driven downward and strikes the hot metal. This impact causes the metal to flow into a new shape. The metal flow is called *plastic deformation*.

In smith forging, the size and shape of the formed product is controlled, in large part, by the operator. A high degree of operator skill is needed. Because so much depends on the skill of the operator, it is difficult to produce consistently accurate parts. Today, few finished shapes are produced using smith forging.

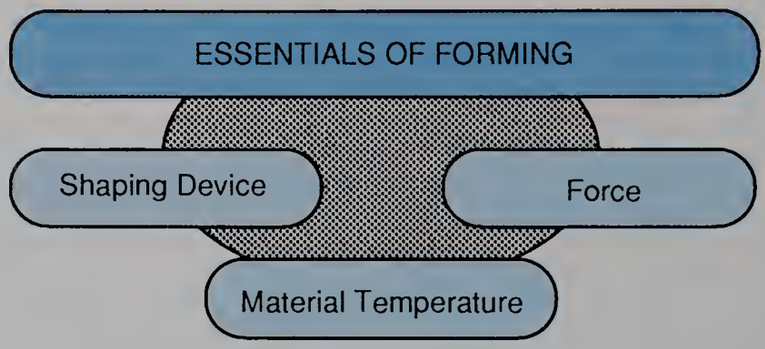


Fig. 8-2. These are the essential elements of all forming processes.

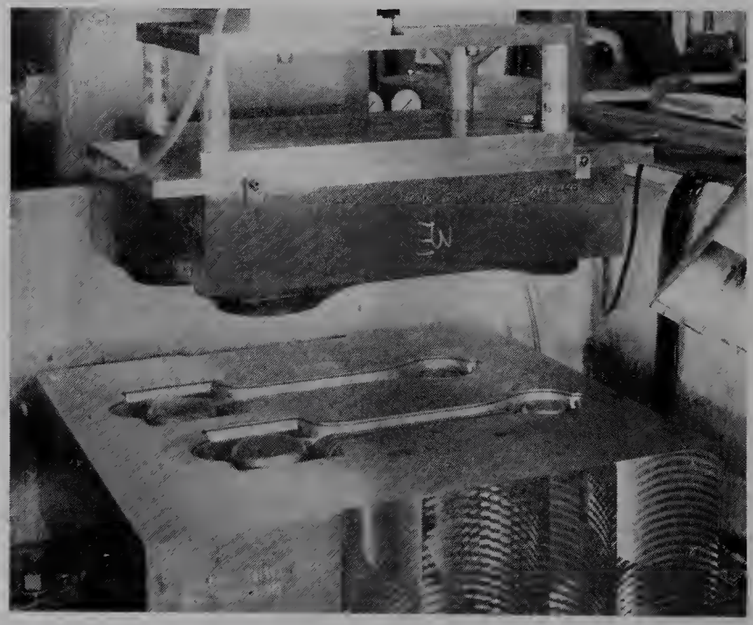


Fig. 8-3. An electrical discharge machine is being used to create a cavity in a block of steel. The result will be one half of a mated die to form automotive engine parts. (Cincinnati Milacron, Inc.)

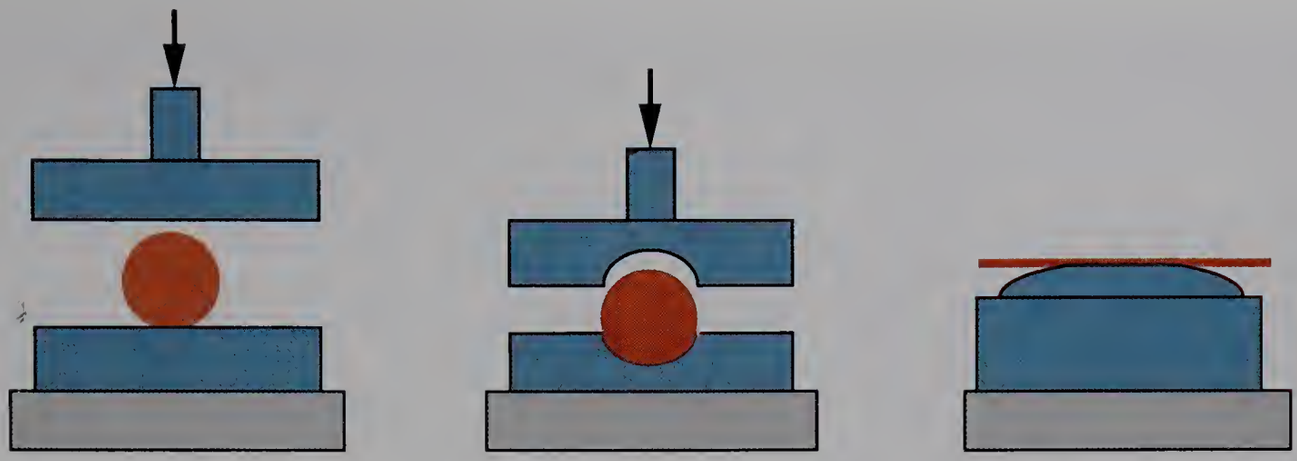


Fig. 8-4. These are types of forming dies.

Mated dies. Most dies have machined or engraved cavities in their faces. These dies, shown in Fig. 8-6, are called **mated dies** or closed dies. When the two halves of the die set close, the material between them takes the shape of the die cavities.

Several important forming techniques use closed dies to form metals, ceramics, and plastics. One of these is **forging**, which is primarily used to form metals. In this process, the metal is heated to a temperature close to its melting point. It is then placed between the two open die halves. The dies are closed with such force that the hot metal flows into the die cavities.

Forging processes may use either a hammer or a press to close the die set. A hammer is used for **drop forging**. The dies are quickly driven or dropped to give a sharp blow. **Press forging** gives a steady, squeezing force. This is provided by a hydraulic ram closing the dies on the material.

Forged parts have high strength because the grain structure produced flows with the part shape, Fig. 8-7. Forging techniques are used to produce items such as aircraft and automotive engine parts, tools, and flatware (knives, forks, and spoons).

Shaped dies. One-piece **shaped dies** can be used to form ceramic, metal, and plastic materials. There are many different processes.

One is **thermoforming**. This process is used to form plastic sheets into packaging trays and covers,



Fig. 8-5. This huge, red-hot metal workpiece is being formed using a forge.



Fig. 8-6. This set of mated dies was designed to forge automotive engine connecting rods. (Forging Industry Assoc.)

freezer boxes, automotive parts, and many other products.

In thermoforming, as shown in Fig. 8-8, sheet plastic is first heated. The hot material is placed over the one-piece shaped die that is called a mold. The air in the mold is evacuated with a vacuum pump. The atmospheric pressure above the hot plastic forces it into the mold where it cools. The cool plastic will retain its new shape.

The thermoforming mold may have a concave cavity into which the plastic is drawn, or the mold may be a convex shape over which the hot material is formed. See Fig. 8-9.

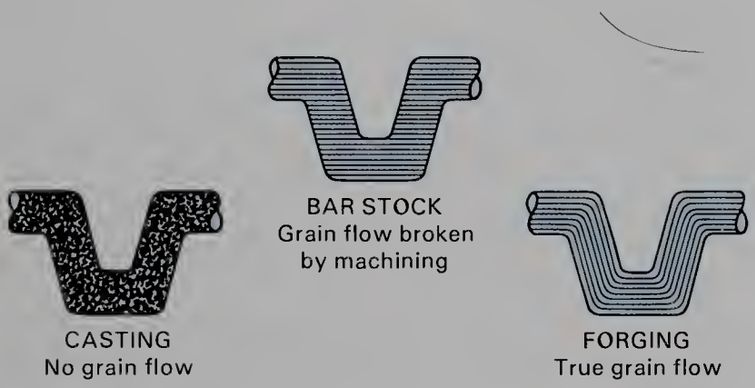
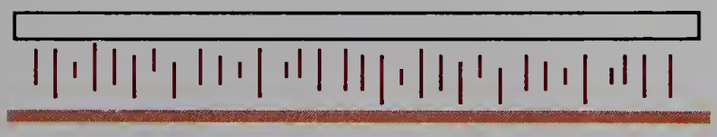
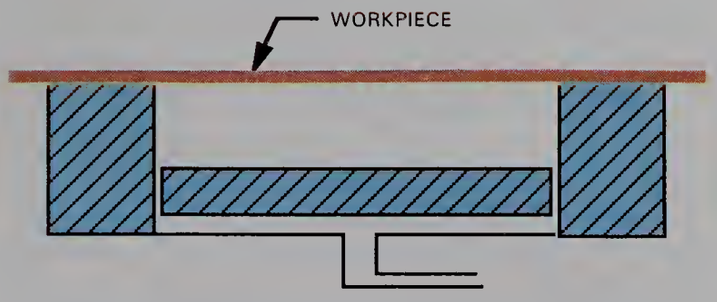


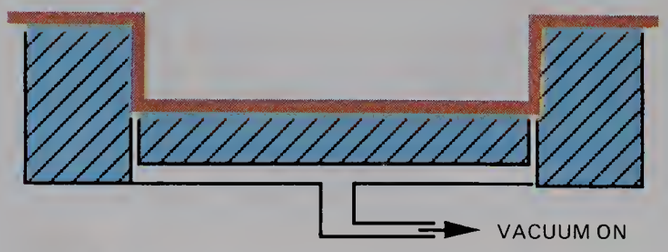
Fig. 8-7. These drawings compare the grain structure of a casting, bar stock, and a forging. (Forging Industry Assoc.)



1. Sheet plastic is heated.



2. Heated plastic is placed over the mold.



3. Plastic is drawn into mold.

Fig. 8-8. This drawing shows the simplest thermoforming technique.

A second process that uses a shaped die is **metal spinning**, Fig. 8-10. The die is called a *chuck*. It is mounted on a headstock of a special lathe. A soft metal disc is clamped between the chuck and a tailstock pad. The lathe is turned on, and a tool applies pressure to the disc. The pressure causes the metal to flow (plastic deformation) around the chuck. The process work hardens the material so that it easily retains the new shape. Many conical parts are formed with metal spinning. These items include reflectors for lighting fixtures and ends for tanks.

Rolls

The second major shaping device is a roll. There are two major types. These are smooth rolls and shaped rolls.

Smooth rolls are used to press materials into a desired thickness during primary processing. They are used to change aluminum and steel ingots into sheets and plates.

During secondary processing, smooth rolls form curves out of sheet metal, tubing, and bar stock. See Fig. 8-11. During this process, the material passes between three rotating rolls. The bottom two rolls are stationary, and support the material. The upper roll can be fed downward. This movement causes the material to flex and curve upward forming an arc. The farther downward the upper roll is fed, the greater the resulting curve is. This process is used to produce round tanks, plates for rocket bodies, and large pipes.

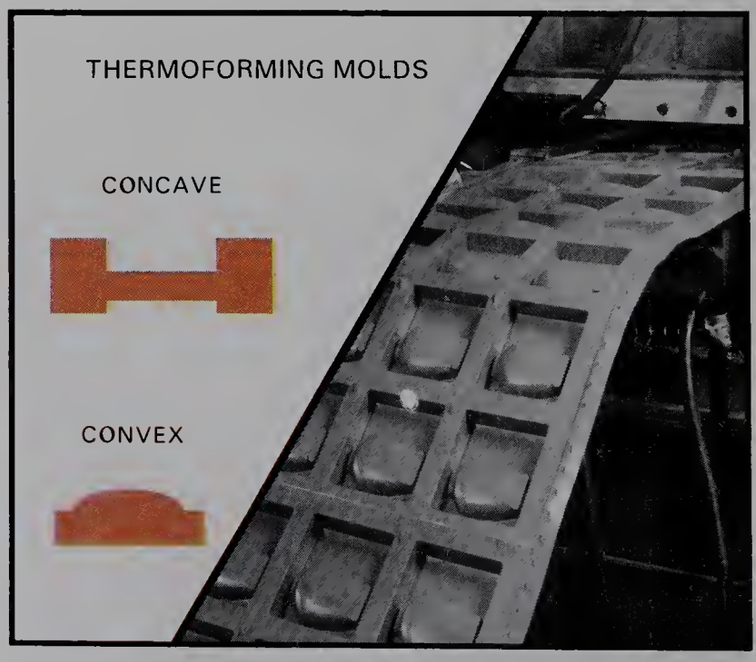
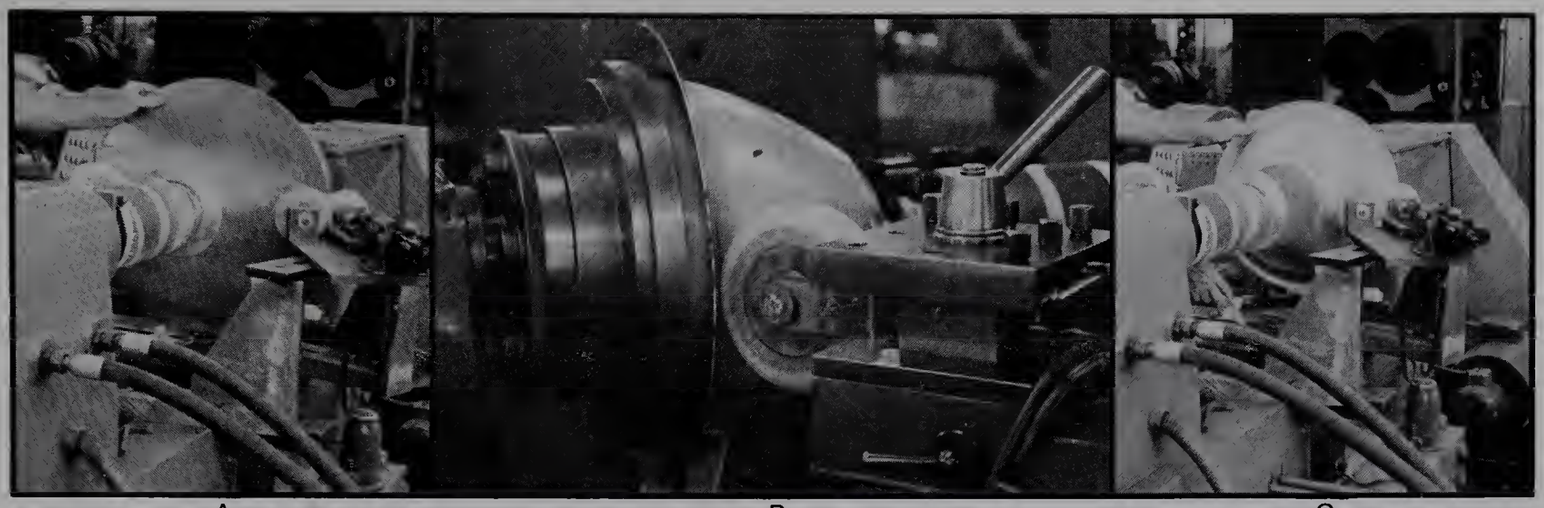


Fig. 8-9. The types of thermoforming molds are listed on the left. A typical thermoformed sheet for electric razor packages is shown on the right.



A B C

Fig. 8-10. The major steps in metal spinning are shown above: A–The aluminum disc is placed in the lathe. B–The rotating disc is formed over the chuck. C–The finished part is removed. (Crouse-Hinds Co.)

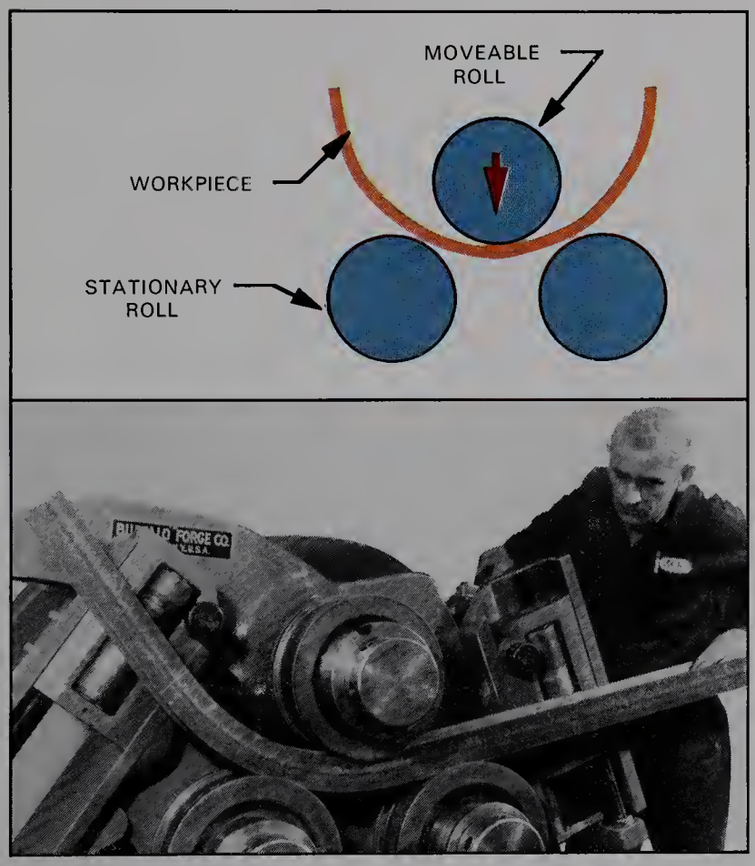


Fig. 8-11. This heavy-duty three-roll forming machine can bend large I-beams into curved structures. (Buffalo Forge Co.)

Some roll forming techniques use **shaped rolls**. These rolls have a series of grooves machined in them. As the material passes through the machine, each set of rolls produces a different part of the new shape. Fig. 8-12 shows a rolling machine that produces corrugated roofing. Notice that each roll produces a set of corrugations starting from the center of the sheet. The workpiece emerges as a completely corrugated sheet.

MATERIAL TEMPERATURE

The temperature of a material is an important consideration in all forming operations. The material must flow into a new shape without becoming a liquid. Generally, the hotter a material is, the easier it is to form.

Forming processes can be divided into two categories, according to the working temperature. These categories are hot forming and cold forming.

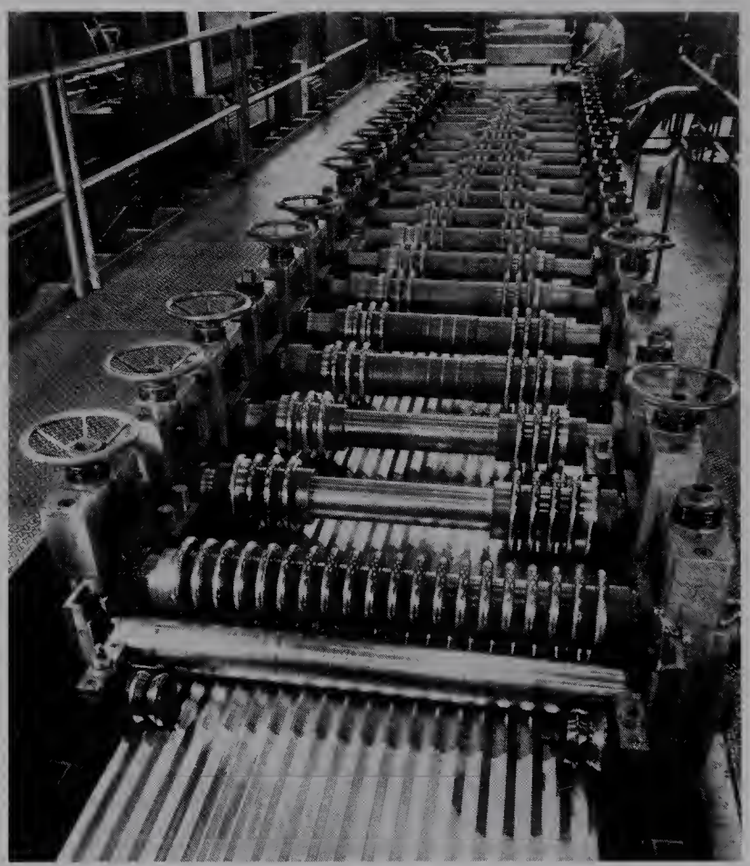


Fig. 8-12. This machine forms corrugated roofing. (Reynolds Metals Co.)

Metals go through several stages as they are heated. At each stage, a material has specific internal crystal structures. At one of these points, the metal can be formed without developing internal stress within the crystal structure. This point is called the *recrystallization point*. All forming techniques that shape materials above this point are called **hot forming** processes.

Among the hot forming processes are metal forging, extrusion, roll forming, and drawing. Plastics are worked hot in thermoforming, blow molding, and extrusion. Ceramics are often blow molded and hot pressed into shape, Fig. 8-13.

Forming done below the recrystallization temperature is called **cold forming**. The material may be at room temperature or it may be heated. Forming done above room temperature and below the recrystallization point is often called **warm forming**.

The choice between cold and hot forming is made after considering several factors. These are included in the chart in Fig. 8-14.



Fig. 8-13. These automobile windshields were hot formed. (PPG Industries)

Cold Forming	Hot Forming
• Produces a smooth, oxide-free surface. • Requires heavier forces. • Improves strength properties. • Creates stress. • Increases hardness.	• Produces surface scale. • Requires lower pressures. • Does not change properties.

Fig. 8-14. These are some of the characteristics of cold forming and hot forming. The choice between cold and hot forming is based upon these characteristics.

TYPES OF FORMING FORCES

Forming is done by using a combination of three basic forces. These, as shown in Fig. 8-15, are:

- Squeezing forces.
- Drawing forces.
- Bending forces.

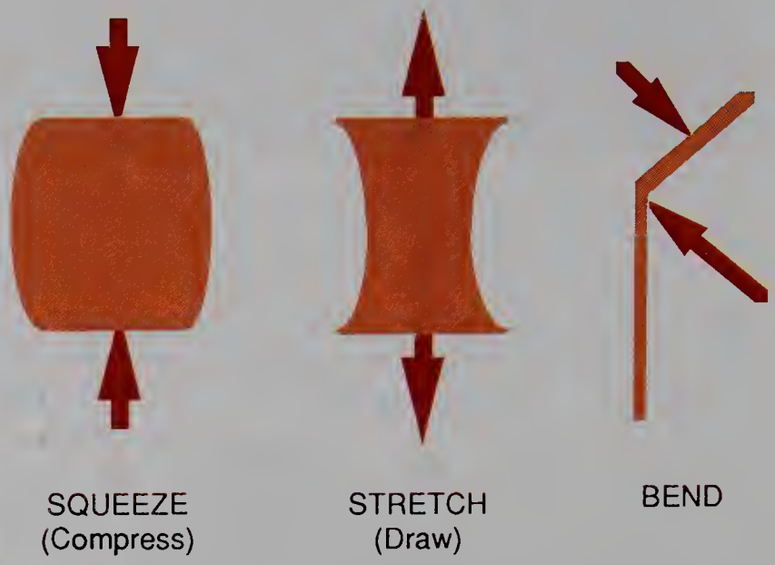


Fig. 8-15. Types of forming forces are shown above.

Squeezing forces

Squeezing forces compress a material to cause plastic deformation. As the material resists this force, it flows into a new shape. An example of a forming process that uses compression is **extrusion**. This technique produces long lengths of material with a common cross-sectional shape, Fig. 8-16.

In this process, a one-piece shaped die is produced. The die has a hole that is the same shape as the cross section of the extrusion. A billet (bar) of material is placed in a chamber behind the die. A ram or plunger is forced into the end on this chamber. As the plunger moves forward, the extrusion material is forced through the die opening. The material's cross-sectional shape will be exactly the same as the die opening. Squeezing toothpaste from a tube is a simple process that is very much like extrusion. Building bricks, concrete blocks, plastic molding, and aluminum sash (window) and door parts are extruded.

Drawing forces

Drawing forces or stretching forces produce a wide variety of metal and plastic products. The aluminum beverage cans, shown in Fig. 8-17, were produced using a *deep drawing* process. In this process, a soft sheet of aluminum was clamped over the lower die half of a mated die set. The upper die half was pressed

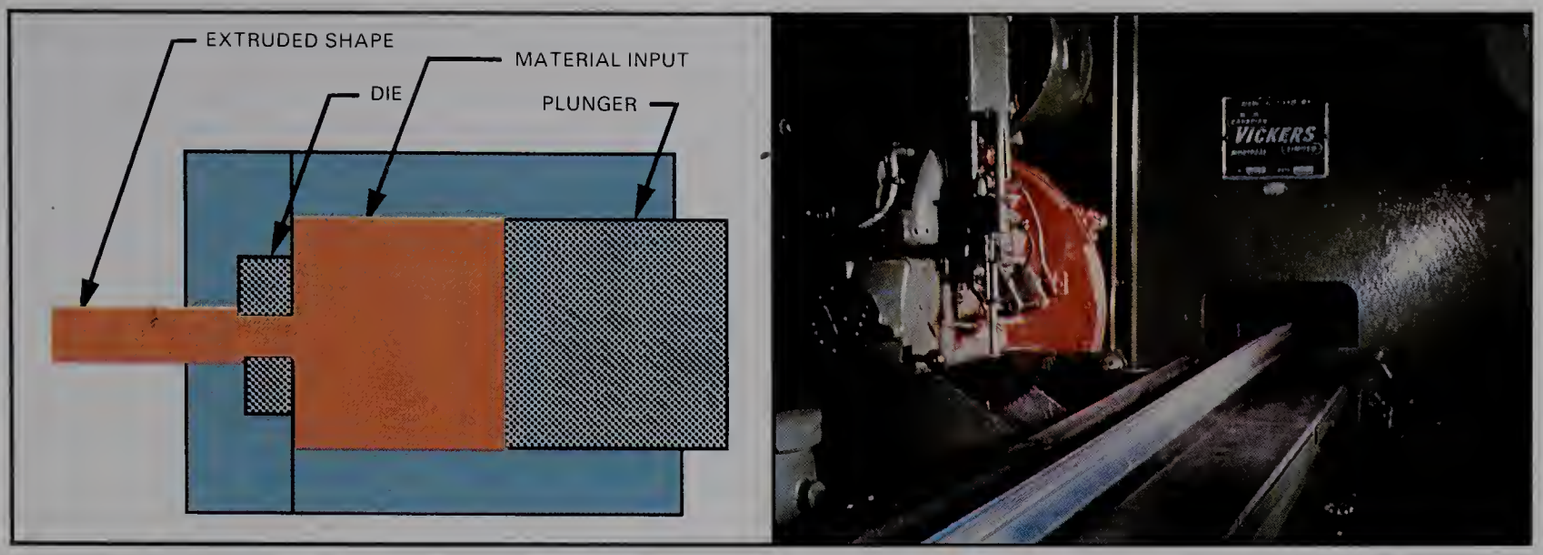


Fig. 8-16. The drawing on the left shows forward extrusion. The photo on the right shows a complex architectural aluminum shape being extruded through a shaped hole in the die. (Alcan Aluminum Co.)

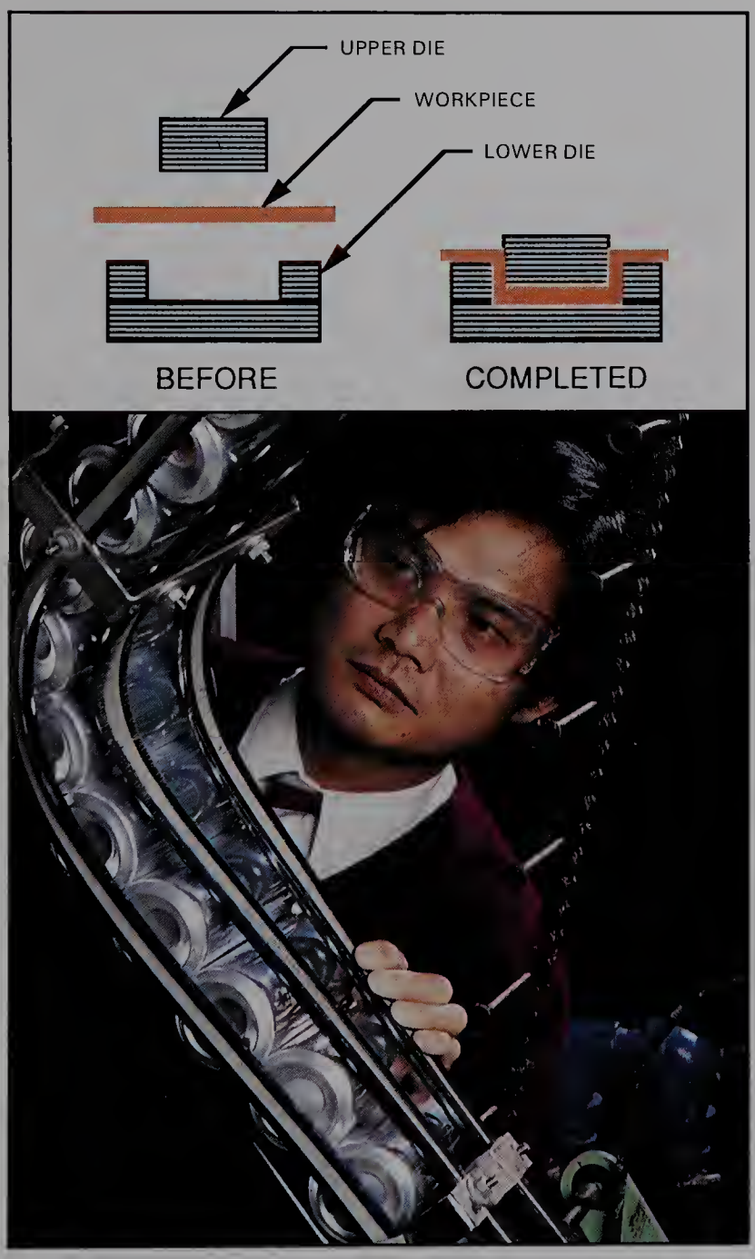


Fig. 8-17. A drawing die, like the one shown in the sketch, is used to form the beverage cans, like those in the photograph. (Reynolds Metals Co.)

into the lower die. This action caused the metal to flow into the lower die cavity creating the finished shape.

Drawing produces items like flashlight battery cases and automotive body parts. Thermoforming, which was discussed earlier in this chapter, also uses drawing forces.

Bending forces

Bending forces are used to form sheet materials, bars, and tubing into new shapes, Fig. 8-18. Bending is done by gripping one end or edge of a material. The free end or edge is then folded or curved around an axis. Bending forces produce straight bends along a sheet or curves in bars, rods, or sheet materials.

SOURCES OF FORMING PRESSURES

Forming forces must be generated by some outside means. Machine tools are the most commonly used source of these forces. Fig. 8-19 illustrates the four basic machines that are used in forming operations. These are:

- Hammers.
- Presses.
- Rolling mills.
- Draw benches.

HAMMERS

Hammers and presses are closely related. This can be seen by studying the diagrams in Fig. 8-19. The main difference between hammers and presses lies in the type of force they deliver.

A **hammer** delivers a sharp blow. Many forging processes use this type of force. The quick, hard blow

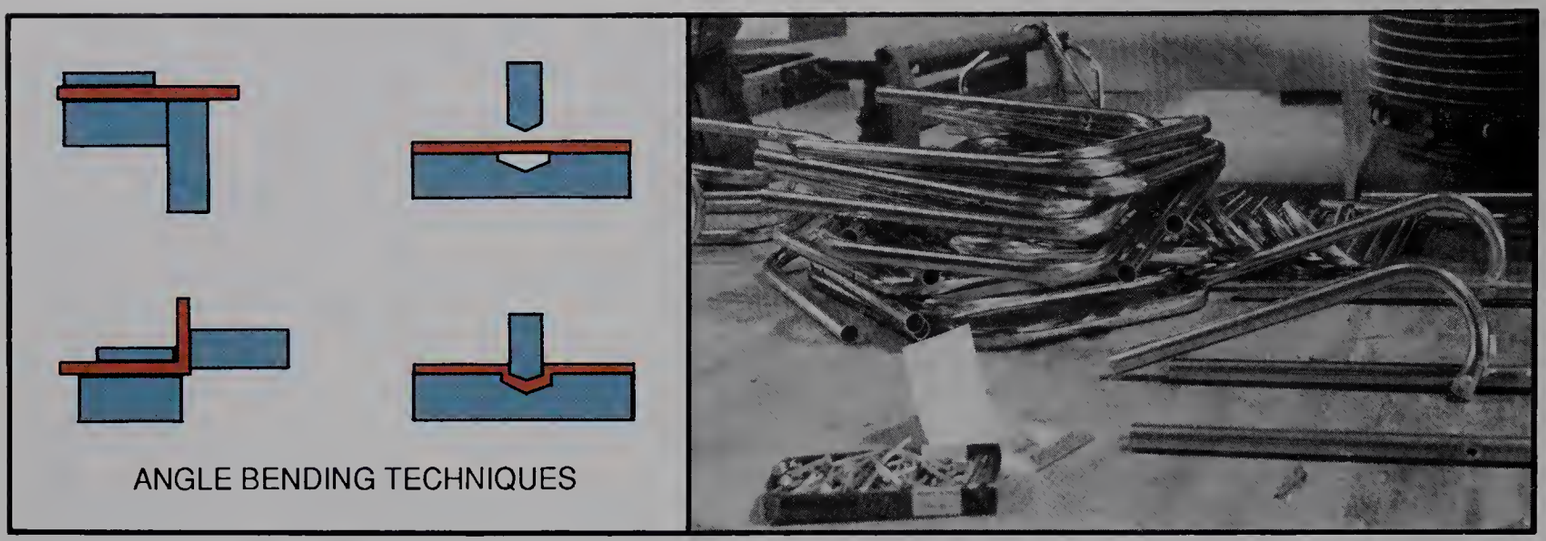


Fig. 8-18. The drawings on the left show angle bending, while the photo on the right shows pieces of tubing that were bent into patio table parts.

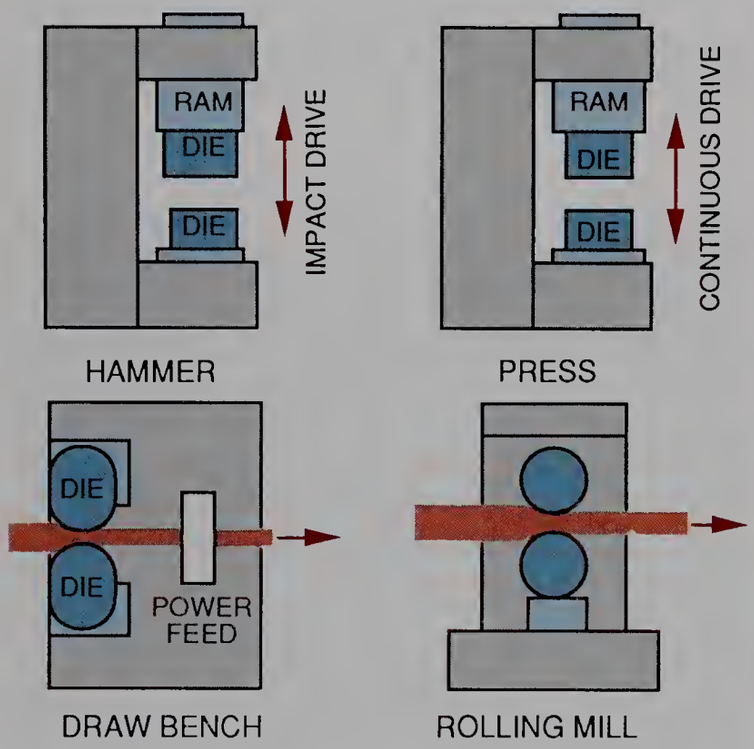


Fig. 8-19. These are machine tools used to generate forming forces.



Fig. 8-20. This hammer is forging a steel part. (Fansteel Inc.)

is delivered by dropping or propelling the movable upper head and die onto the bottom die, Fig. 8-20. Some operations use a drop hammer that simply releases the upper die and plunger. The weight of the falling die assembly delivers the impact. Other hammers use either steam or hydraulic pressure to drive the upper assembly downward, which delivers a rapid blow.

PRESSES

A **press**, like a hammer, has a movable head to which a die is attached. Unlike the hammer, the press moves the head in the steady squeezing action needed for drawing, bending, shearing, and press forging.

Presses can be used for both forming (contour producing) and shearing (shape producing, cutting) activities. Often, these two processes are combined into one die to produce a metal part called a *stamping*. See Fig. 8-21.

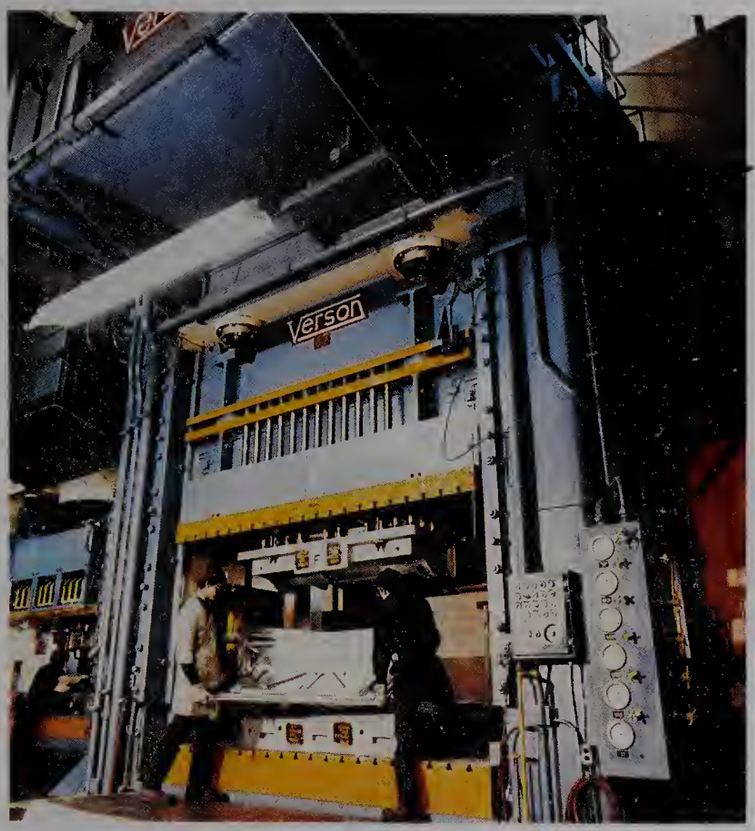


Fig. 8-21. These workers are removing a metal stamping from a forming press. (Budd Co.)

ROLLING MACHINES

A **rolling machine** or roll is the third type of forming machine tool. It has two or more smooth or shaped rolls. They revolve in opposite directions producing the required forming forces.

The force generated between the rolls draws the material into the machine and changes its thickness or shape. The amount of change that can be developed in one pass through a rolling machine will be determined by the type of material being formed, its hardness, and its temperature.

DRAW BENCH

A **draw bench** is a forming machine with a one-piece shaped die. As shown in Fig. 8-22, a draw bench can be used to draw metal rods into wire. In this *wire drawing* process, the rod is pulled through a number of dies. Each die has a smaller hole than the one before it. Therefore, the rod is drawn into finer and finer wire until the desired diameter is reached.

Draw benches can also be used for *stretch forming*, Fig. 8-23. In this process, the material is gripped at its

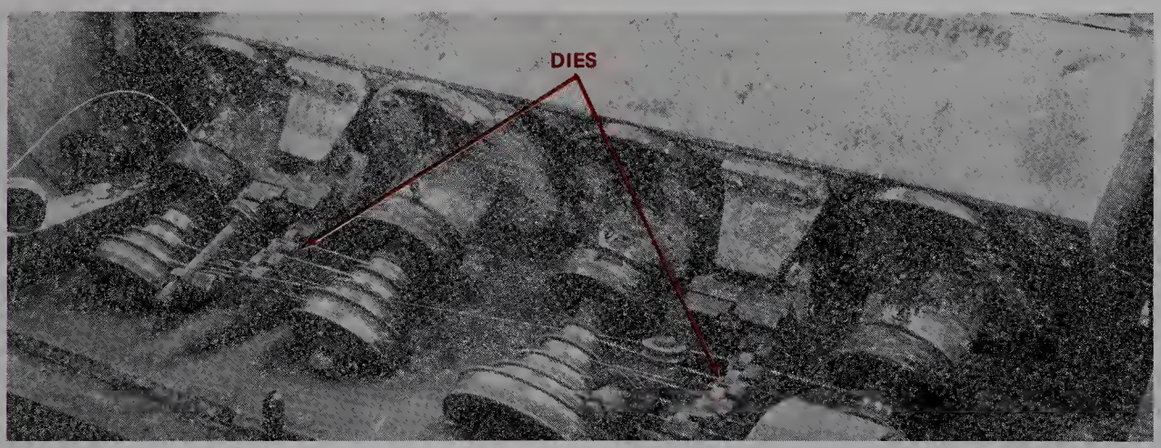


Fig. 8-22. This wire drawing machine is producing wire from thicker metal stock. The wire is entering from the left of the picture and passes through several dies where its diameter is reduced. (The Wire Assoc.)



Fig. 8-23. This large stretch forming press can lengthen a 40-foot sheet of aluminum to 44 feet. It applies 1,000,000 pounds of force. The machine is being used to form aircraft fuselage skin. (Lockheed Aircraft Corp.)

ends. The grippers move outward to stretch and pull the material tight. Then a die under the material is forced upward. The material under stress takes the shape of the upwardly moving die. This process is used to form large sheet metal shapes for the aircraft industry.

OTHER FORMING FORCES

Machine tools are not the only source of forming forces. Air pressure and high energy sources can also be used.

A typical process using air pressure is **blow molding**. This process produces the plastic and glass jars and bottles you see every day. Fig. 8-24 shows a glass bottle blow molding machine in operation. In this process, a glob of hot glass is formed. It is dropped into an open steel mold. The mold closes, pinching off the glob forming the neck of the container. Air is then blown into the glob causing the glass to expand outward against the mold walls. After the glass cools enough to hold its shape, the mold opens. The finished container is ejected.

High energy rate (HER) actions provide another source of forming pressures. The two major HER forming techniques are explosive forming and electromagnetic forming.

In **explosive forming**, a sheet of material is clamped in a steel container, Fig. 8-25. The lower half of the container is the die with a shaped cavity in it. The upper half is the explosion chamber that is filled with air or a liquid. An explosive charge is detonated in the chamber. The shock waves from the explosion drive the material downward where it takes the shape of the die cavity.

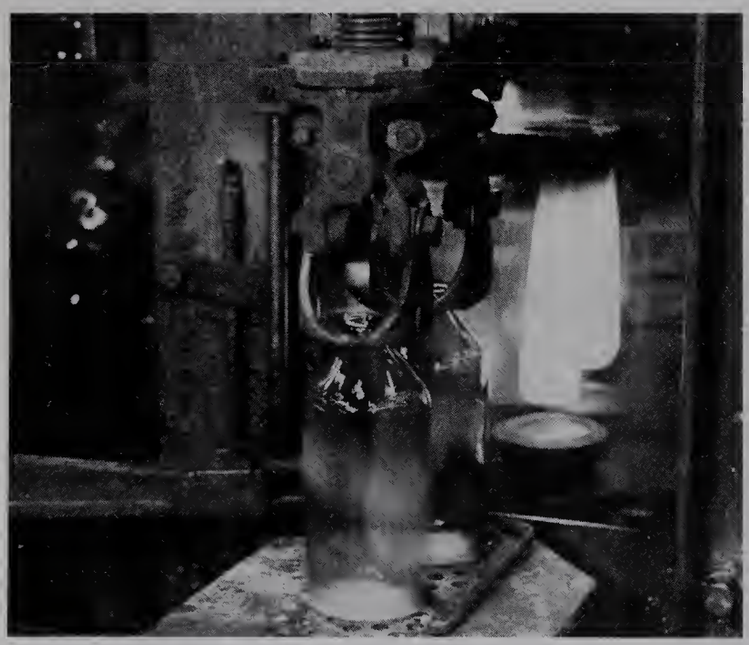


Fig. 8-24. Globules of hot glass enter and molded bottles leave this blow molding machine. (Owens-Illinois, Inc.)

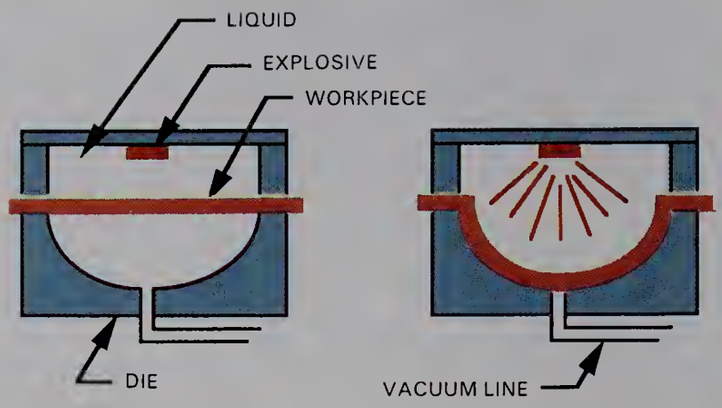


Fig. 8-25. This simple illustration shows explosive forming.

Electromagnetic forming, as seen in Fig. 8-26, uses the magnetic field formed around a coil to form materials. The material to be formed is placed inside the coil. Its high electrical charge is rapidly discharged through the coil. This causes a very strong magnetic field to quickly develop around the coil. The magnetic forces induce current in the workpiece and cause a permanent change in its shape. This process is used to shrink steel tubing around steel parts. The ends of automotive struts are attached to the strut body using this process.

SUMMARY

Forming is a widely used family of processes that provide contour to materials. These processes use shaping devices to change the shape of materials by applying force above the material's yield point and below its fracture point.

Forming operations squeeze or compress, draw or stretch, or bend materials. In all cases, however, the material takes on a permanent shape without changing in weight or volume.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

bending forces
blow molding
cold forming
dies
draw bench
drawing
drawing forces
drop forging

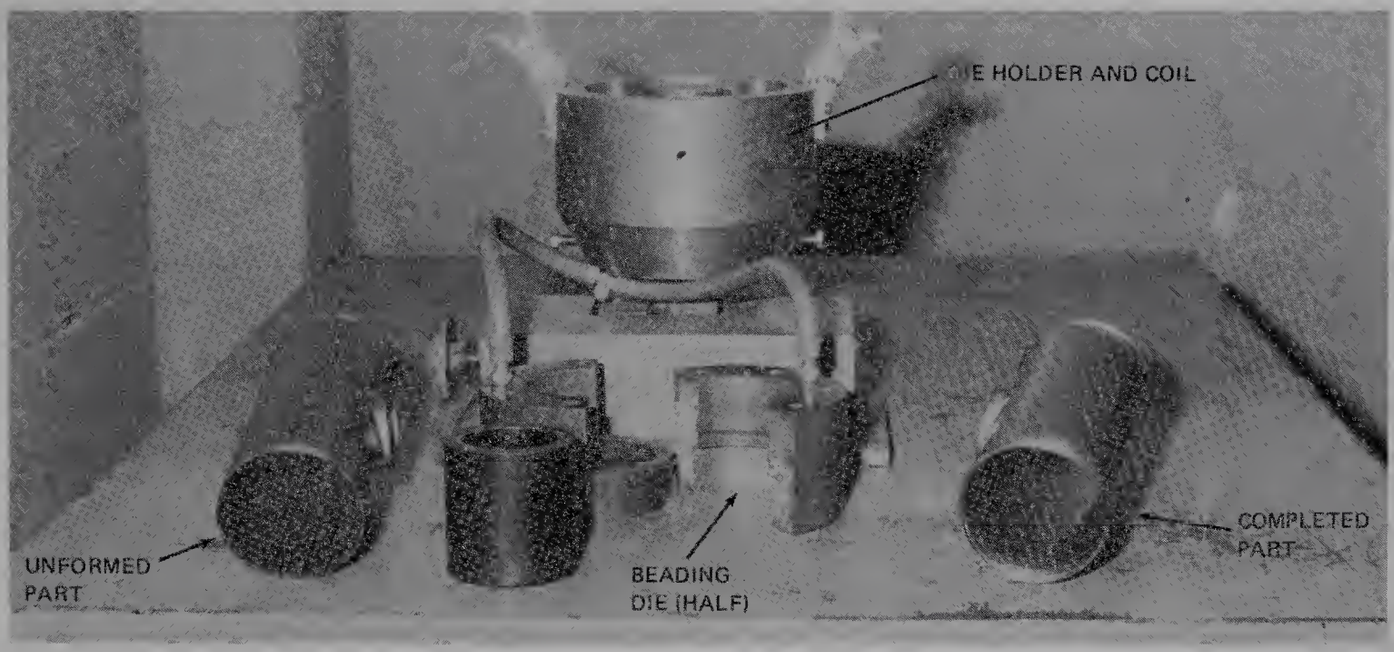


Fig. 8-26. Beads are formed on the ends of titanium aircraft parts using an electromagnetic forming process. (Boeing Co.)

electromagnetic forming
explosive forming
extrusion
forging
fracture point
hammer
hot forming
mated dies
metal spinning
open die
press
press forging
rolling
rolling machine
shaped die
shaped rolls
shaping device
smooth rolls
squeezing forces
thermoforming
warm forming
yield point

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. The first forming method used to shape metals was:
   a. Melting.
   b. Rolling.
   c. Hammering.
   d. None of the above.
2. List the three essential elements that must be present in order for forming processes to take place.
3. Name the two major types of shaping devices used in forming processes.
4. Explain why few finished shapes are produced using open dies.
5. Generally, the _____ (hotter, colder) a material is, the easier it is to form.
6. Extrusion is an example of a:
   a. Squeezing force.
   b. Drawing force.
   c. Bending force.
   d. None of the above.
7. True or False? Unlike the hammer, the press moves the head in the steady squeezing action needed for drawing, bending, shearing, and press forging.
8. List the two high energy rate (HER) actions that provide forming pressures and describe each process.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Manufacture a part or product using a common forming process.
   a. Select an appropriate product. This might be a tack puller or screwdriver blade, Fig. 8-A. It will fit the handle you may have made in the casting activity for Chapter 7.

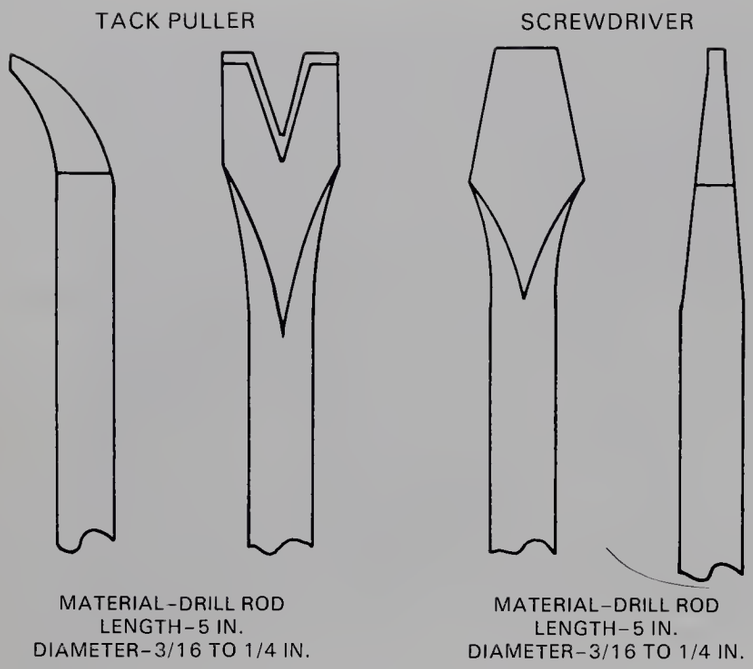


Fig. 8-A. Manufacture a tack puller or screwdriver blade using a common forming process described in this chapter.

b. An alternative might be to produce a set of injection molded checkers for the checker board described in the separating activity for Chapter 9.
c. Whatever your project, make sure you have a set of procedures worked out before you begin. Check the procedures with your instructor. Be sure to include all the operations needed to complete the product. Try to determine which operations should be done first. Select the most appropriate machines or tools in your laboratory to accomplish all tasks.

2. Talk with someone who has made a pie crust. What forming process did the person use to achieve the proper crust thickness?
3. Obtain a flat piece of metal. Use a hammer to cause it to bend into a right angle curve. Carefully examine the metal and describe the effects of this bend forming action.

9

CHAPTER

SEPARATING PROCESSES

After studying this chapter, you will be able to:

- *Distinguish between the processes of machining and shearing.*
- *Describe how the various separating processes developed.*
- *List the three essential elements of separating processes.*
- *Name six basic machines that have been developed to separate materials.*
- *Explain how separating machines operate.*

As discussed in previous chapters, materials may be sized and shaped using casting and forming techniques. Another family of processes to accomplish this task is separating. Separating processes remove excess material, creating the desired size and shape of a workpiece or part.

The two major ways to separate materials are machining and shearing. **Machining** changes the size and shape of materials by removing the excess material in the form of chips or small particles. **Shearing** uses opposed edges to fracture the excess material away from the workpiece.

HOW SEPARATING DEVELOPED

Early humans used crude separating practices as they cut (sheared) meat and other foods with stone tools. Soon they learned to separate wood and stone materials to create useful items. Using crude axes and knives, they produced tools and shelters, harvested plants, hunted game, and caught fish.

Later, they developed the ability to use tools to drill holes in various materials. The bow drill, Fig. 9-1, was possibly the first successful design for a hole-drilling tool. Other early separating devices include the saw, chisel, and knife.

As humans moved into the Iron Age, machines were needed to work metals. One of the earliest power-driven metal-cutting machines was the lathe. This machine allowed the workers to produce accurate round parts such as axles and shafts. The lathe was used in Europe before the Middle Ages (about 500 to 1400 A.D.) Early clockmakers used the lathe quite often in their precision metalworking activities. Later, lathes, like the one shown in Fig. 9-2, were developed for heavier metal machining operations and played an important part in the industrial revolution.

Still other machines followed the development of the lathe. One of these machine tools, called a *milling machine*, was developed in the 1800s. See Fig. 9-3.



Fig. 9-1. Separating materials became easier when our ancestors invented the bow drill to produce holes.

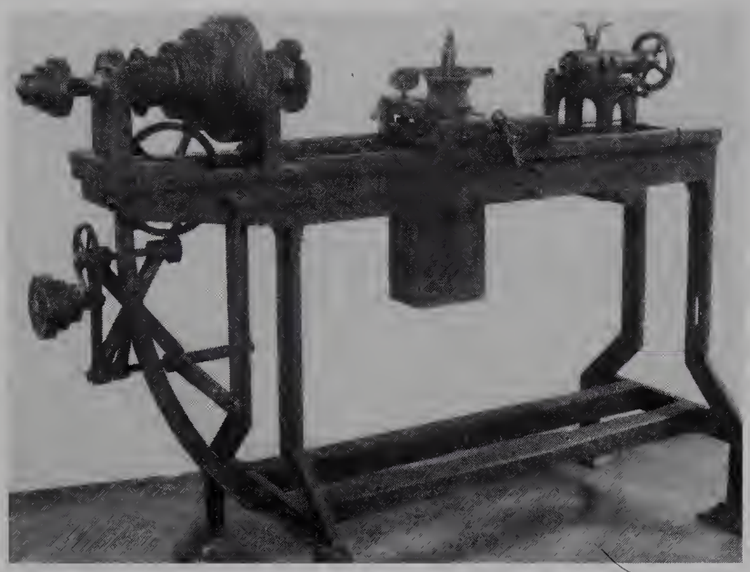


Fig. 9-2. This metal lathe, built in America around 1840, was a big improvement over the lathes invented in the fifth century. (Collections of Greenfield Village and the Henry Ford Museum)

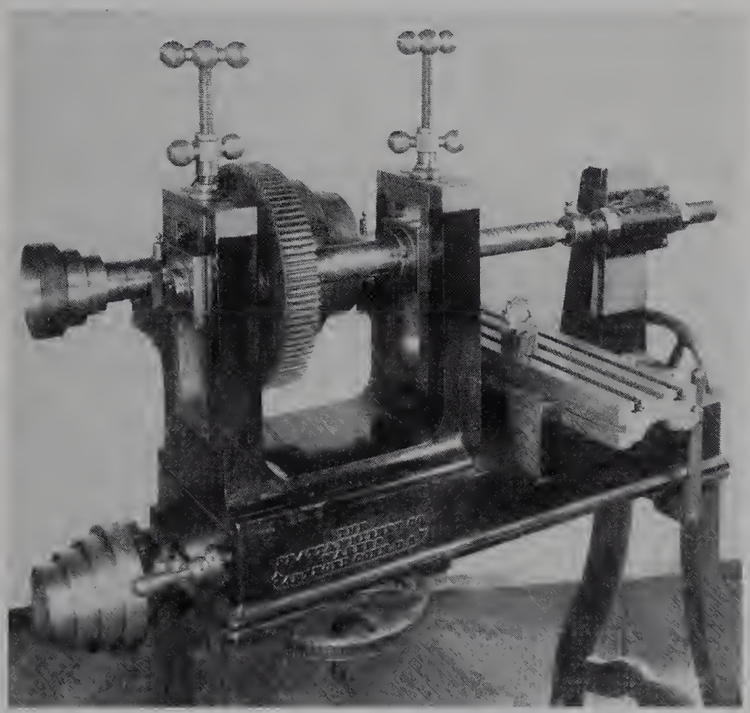


Fig. 9-3. This early milling machine was used in about 1870. It is now a museum piece. (Collections of Greenfield Village and the Henry Ford Museum)

This machine allowed the artisan to cut notches and to smooth the surfaces of flat stock. Eli Whitney used this machine tool in his early development of interchangeable parts for muskets. Other separating machines developed for the industrial revolution included:

- Power driven saws.
- Metalworking shapers and planers.
- Grinding machines.
- Shearing machines.

America has developed one of the greatest production capacities the world has ever experienced. Separating and shearing machines are the foundation of this production system. These machines shape and size materials into interchangeable parts. They are used to build the jigs, fixtures, templates, and patterns that support other manufacturing processes. Separating machines are also used to make other machines that produce the parts for everyday products.

ESSENTIAL ELEMENTS OF SEPARATING

All separating activities share some common characteristics. These essential elements of separating, as shown in Fig. 9-4, are:

- A tool or other *cutting element* is always used.
- There is *motion* between the work and the cutting element.
- The work or the tool is given *support* (clamped or held in one position).

TOOLS OR CUTTING ELEMENTS

Separating processes can be grouped according to the cutting elements used. The major differences among separating processes are shown in Fig. 9-5. Shearing and machining by chip removal use a cutting tool that is called either a cutter or a blade. **Cutting elements** are made from materials that are harder than the material to be cut. Modern cutting tools are usually made from tool steel or ceramic materials (carbides).

Other separating processes use burning gases, light and sound waves, or electrical sparks to separate materials. High pressure liquids can also be used in separating processes.

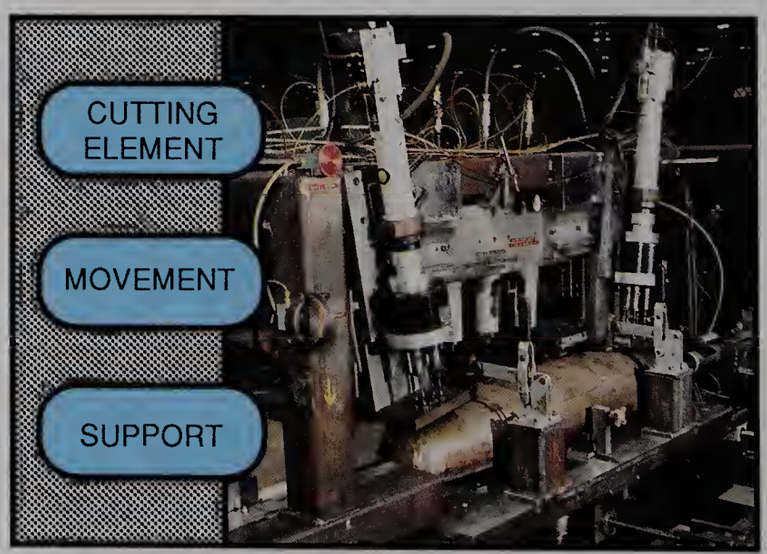


Fig. 9-4. Can you identify the three essentials of separating in this specially built drilling machine? (ARO Corp.)

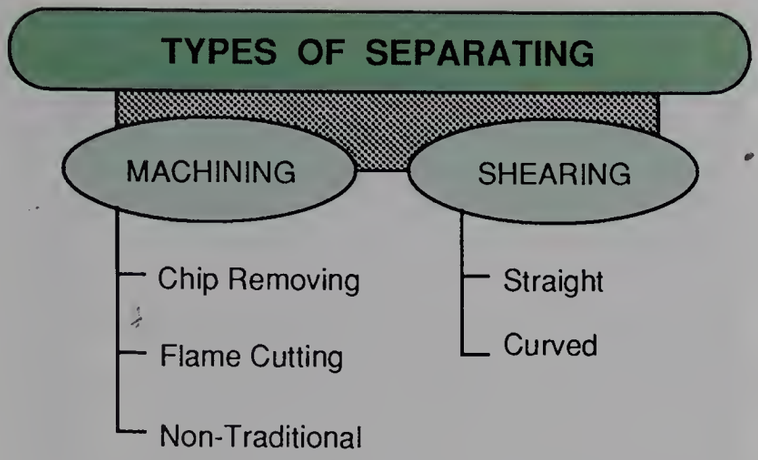


Fig. 9-5. These are the two major separating process with their subdivisions.

Chip removing tools

Traditional (chip removal) machining and shearing is based on the hardness properties of materials. Any material will cut a softer material. For instance, a diamond will cut glass. Carbides will cut tool steel, and tool steel will cut mild steel. Carbon steel will cut wood and nonferrous metals. Cardboard (a wood product) will cut butter.

When the material is properly shaped, the resulting cutting element is called a *tool*. All tools may be divided into two classes:

- Single point tools.
- Multiple point tools.

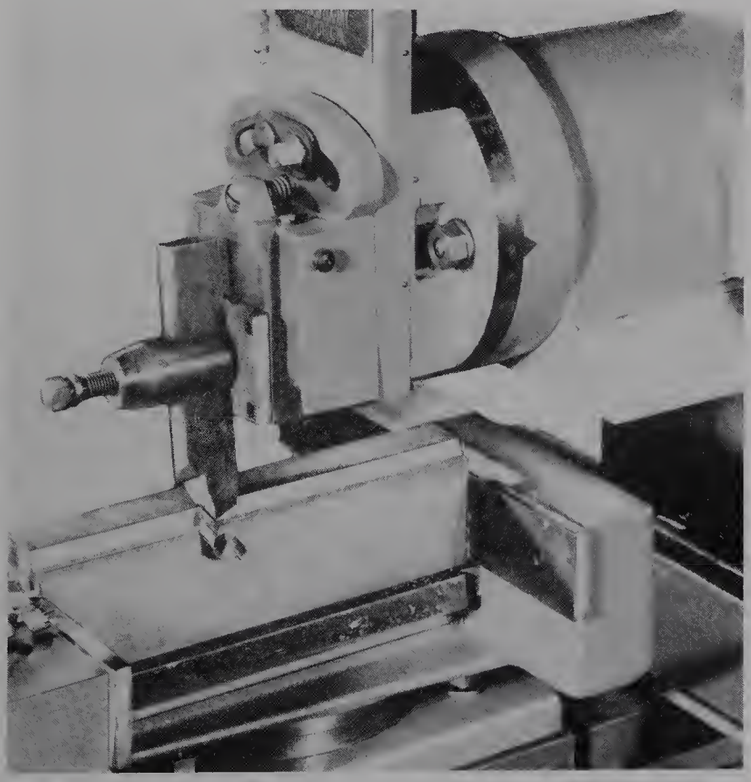


Fig. 9-6. This metal shaper tool is an example of a single point cutting tool. Notice the chip it is forming. (Rockford Machine Tool Co.)

Single point tools, like the one shown in Fig. 9-6, are the simplest of all tools. They have one cutting edge that forms the chip. Most lathe, metal shaper, and metal planer tools are single point devices. Woodworking planes, chisels, scrapers, and gouges are common single point hand tools.

Multiple point tools, Fig. 9-7, are two or more single point tools arranged to form a cutting device. Each point of the tool acts like a single point tool. Arranging several single point cutting edges into a multiple point tool speeds the cutting process.

Several types of equipment use multiple point tools. These include circular, band, and hack saws; woodworking shapers, planers, and jointers; drill presses; sanding and grinding machines, and routers.

The cutting points on multiple point tools are arranged in two major patterns. Some are randomly arranged, while others have a set pattern.

With abrasive cutting devices, such as abrasive papers and grinding wheels, the single point cutting edges (abrasive grains) are randomly arranged. They have no set pattern or spacing.

Cutters, such as saw blades and milling cutters, have a specific pattern to the cutting points. They are carefully spaced around the cutter in a pattern to generate the cutting action, Fig. 9-8.

Cutting tool design

Cutting tools come in many shapes and types. The material to be cut and the machine that will do the cutting help determine the tool to be used. However, each cutting surface of a tool must be properly



Fig. 9-7. Most cutting tools are multiple point devices. (Inland Steel Co.)

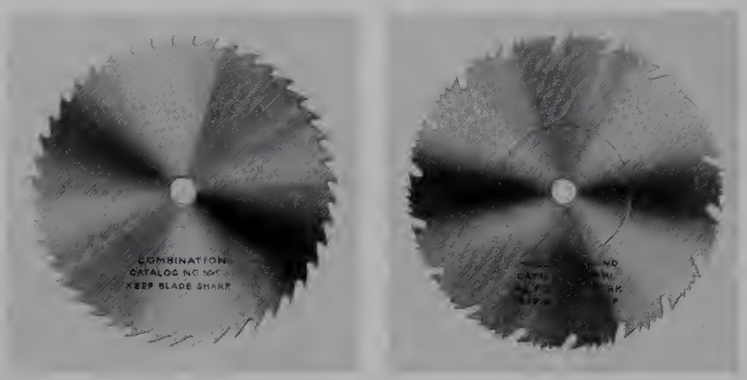


Fig. 9-8. These saw blades are examples of multiple point cutting tools. Notice that each blade has a different tooth arrangement. However, the teeth on each blade have the same basic spacing and shape arrangement. (Delta International Machinery Co.)

designed. The tool designer must consider at least four factors:

- Each tooth must be the correct shape to develop a chip and to produce a desired contour to the material, Fig. 9-9.
- Sharp points are avoided whenever possible. They wear rapidly and are easily broken or chipped. To test this, try to cut a piece of wood first with a knife point and then with the edge of the blade. You will obtain a cleaner cut with the edge of the knife.
- **Relief angles** must be provided behind all parts of the cutting edge that generates the chip, Fig. 9-10. These angles prevent the body of the cutter from rubbing against the material and creating excess heat. Also, without relief angles, the cutting edge cannot easily penetrate the material. Using your knife again, lay the blade flat on the wood. You cannot get it to cut. Also, if you rub it back and forth, the blade will become hot. Now tilt the blade up at a 10 to 15° angle. The blade will cut the material.
- **Rake** is required on all cutting edges. This angle, as shown in Fig. 9-11, is sloped away from the cutting edge. Rake reduces the force it takes to produce a chip and lifts the chip away from the material.

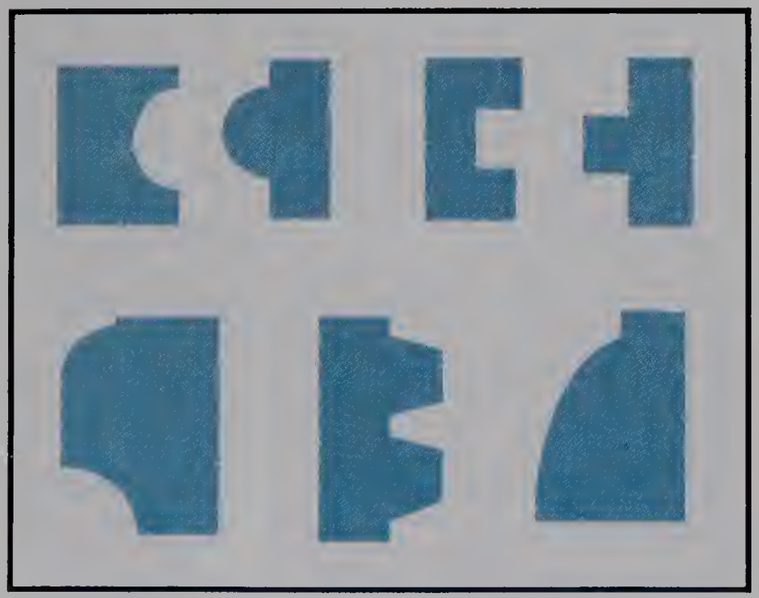


Fig. 9-9. These are some of the common shapes that are available in multiple point wood shaper cutters.

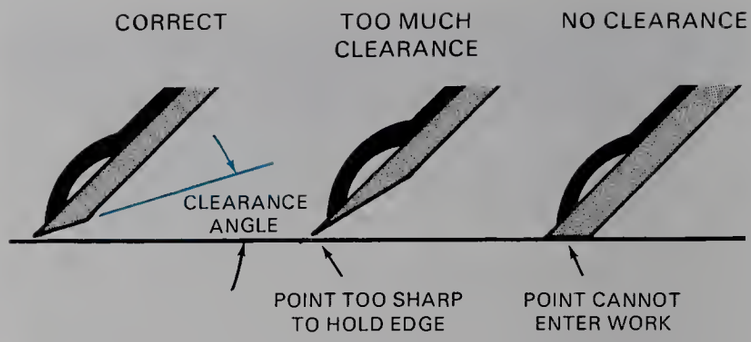


Fig. 9-10. Cutting tools must have relief angles if they are to cut properly.

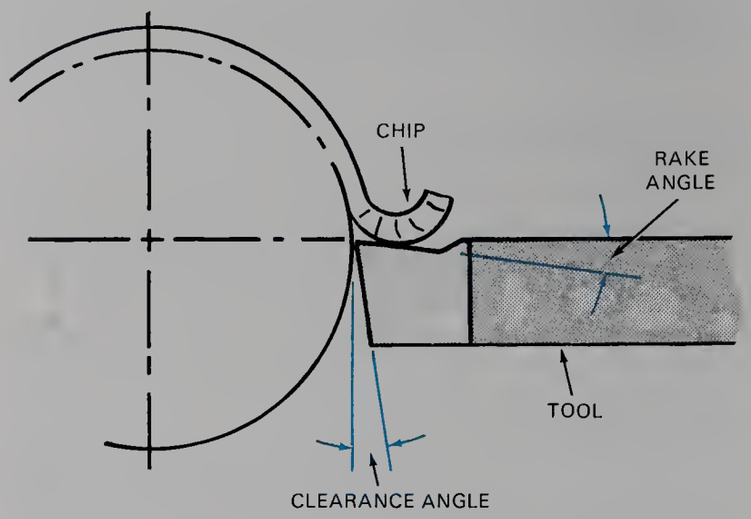


Fig. 9-11. This diagram shows the typical rake and clearance angles that must be developed when producing a single point metal lathe tool.

Non-chip cutting elements

Nontraditional machining and flame cutting do not use a tool in the normal sense of the word. These processes rely upon electric arcs, sound waves, light beams, chemical reactions, and burning gases to separate excess material from the workpiece. Many times, the "chip" is a fine particle of material or a glob of molten metal.

Flame cutting is probably the oldest of the non-chip separating processes. With this process, a mixture of gas (usually oxygen and acetylene) is burned to melt a path between the part and the excess material, Fig. 9-12. The flame preheats the metal. Then a stream of oxygen causes the base metal to oxidize rapidly. This chemical reaction turns the metal into



Fig. 9-12. This worker is monitoring a multiple head, computer-controlled flame cutting machine. (Federal Industries)

its molten state. The liquid metal falls away from the cooler metal on each side of the cutting path.

The oldest of the nontraditional machining processes is **electrical discharge machining (EDM)**. This process, which is shown in Fig. 9-13, uses a shaped carbon electrode or tool that is mounted on a movable head. The workpiece is placed in a dielectric liquid (nonconductor of electricity). The tool is slowly lowered until an electric arc jumps between the workpiece and the tool. The spark becomes the cutting element and dislodges fine particles of the workpiece. As this erosion continues, the tool is fed downward, creating a shaped cavity in the part.

EDM is widely used to produce accurate cavities in forging and stamping dies and in very hard metallic materials. Recently, processes similar to EDM have been developed. All of them use an electrical spark between a tool and the work as a cutting element. The most common of these processes are:

- **Electrical discharge grinding (EDG):** This process removes material using an electrical spark between a rotating disc and the work as a cutting tool.
- **Electrical discharge sawing (EDS):** In this process, an electrical spark between a moving knife edge band and the work serves as a cutting tool.
- **Electrical discharge wire cutting (EDWC):** The cutting tool for this process is an electrical spark between a taut, traveling wire and the work.

Recently, additional processes have been developed using nontraditional cutting elements. The simplest of these is **chemical machining**. This process uses the same chemical action that causes metal to corrode (rust or tarnish). In chemical machining a photographic negative of the area to be machined is

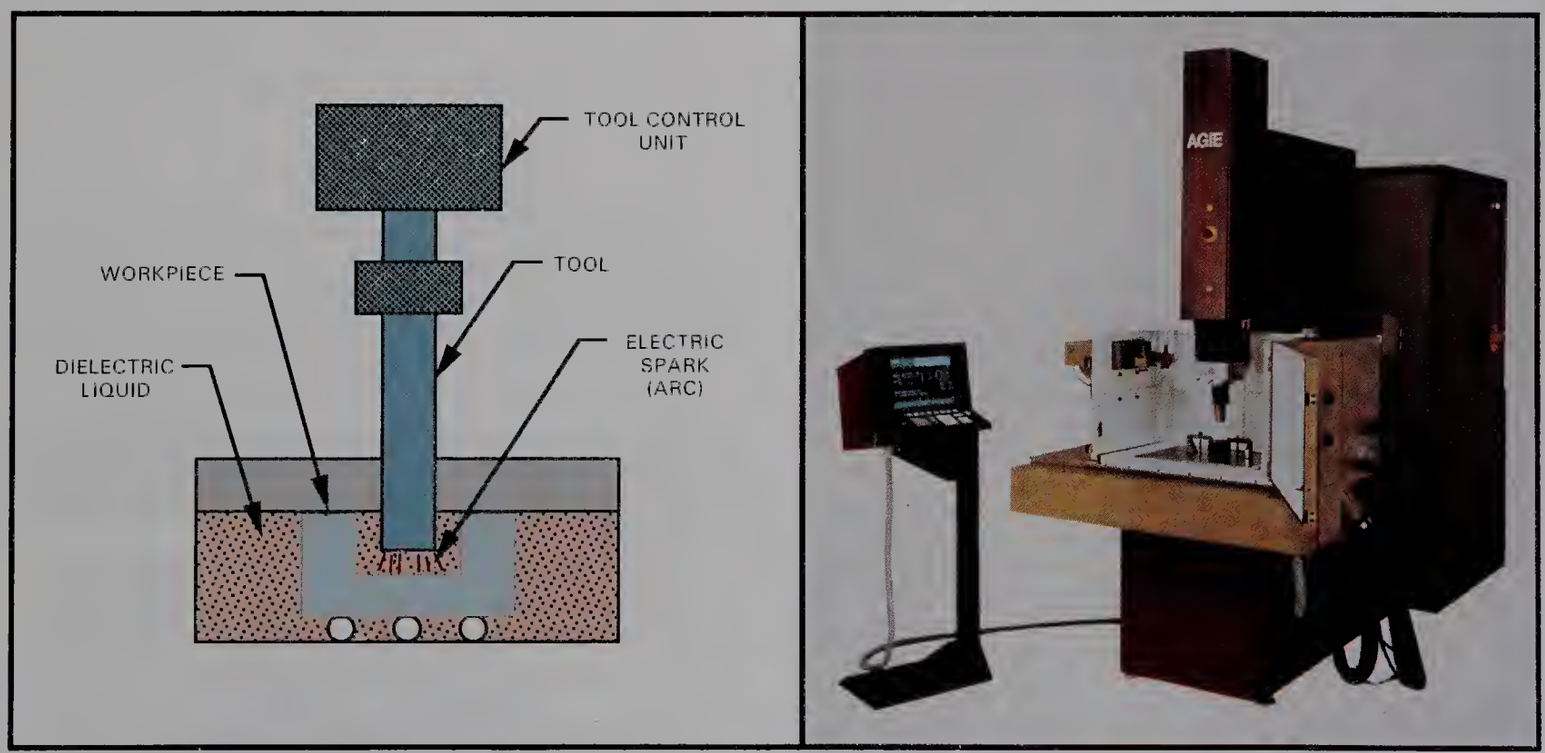


Fig. 9-13. The principle shown in the drawing on the left shows how the EDM machine on the right operates. (AGIE USA Ltd.)

produced. The metal is cleaned and coated with a *photoresist*. (This is a material that will react to strong light.) The negative rests upon the coated metal while a powerful light exposes the resist through the negative. The resist is developed with chemicals much like a photographic print is developed. This leaves the area that is to be machined uncoated. Then chemicals, which attack and etch (eat away) the uncoated area, are applied to the workpiece.

Another new, nontraditional machining process uses beams of focused light as a cutting element. This process, called **laser beam machining (LBM)**, directs a concentrated beam of monochromatic (one color) light on the work. The light produces intense heat that melts a path in the material, Fig. 9-14. Laser cutting can be used on a wide variety of materials ranging from paper and wood to metal and ceramic.

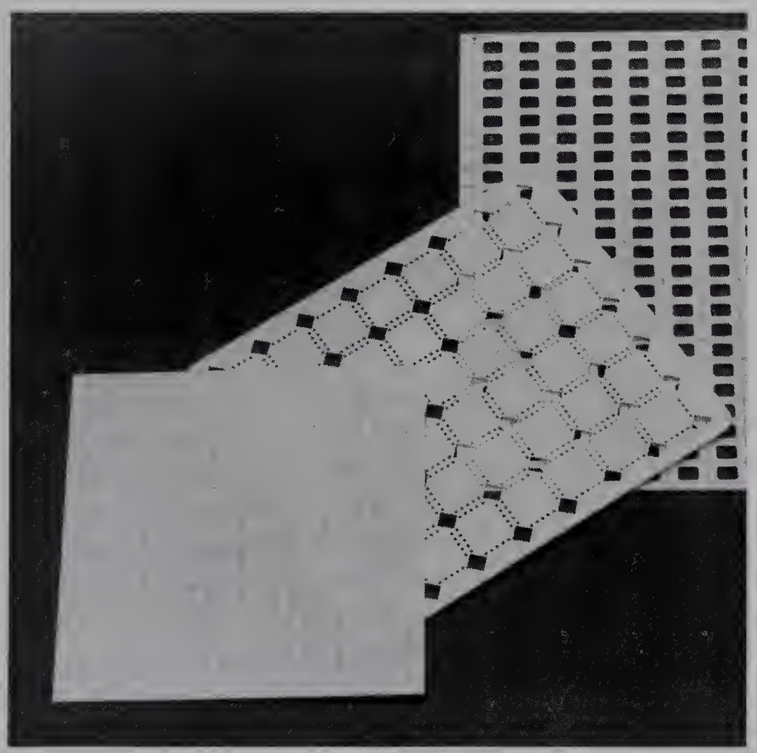


Fig. 9-14. The openings in these ceramic sheets were cut by lasers. (Coherent)

MOTION

All separating operations use motion between the tool and the cutting element. There are generally two types of motion. These, as shown in Fig. 9-15, are:

- Cutting motion.
- Feed motion.

Cutting motion

Cutting motion is movement between the work and the cutting element that causes material to be removed. Cutting motion can be generated by three basic types of movement, Fig. 9-16. The tool or the work can **rotate** or revolve to create the motion. The work or the tool may **reciprocate** (move back and forth). A **linear** or straight-line motion may also be used to produce the chips.

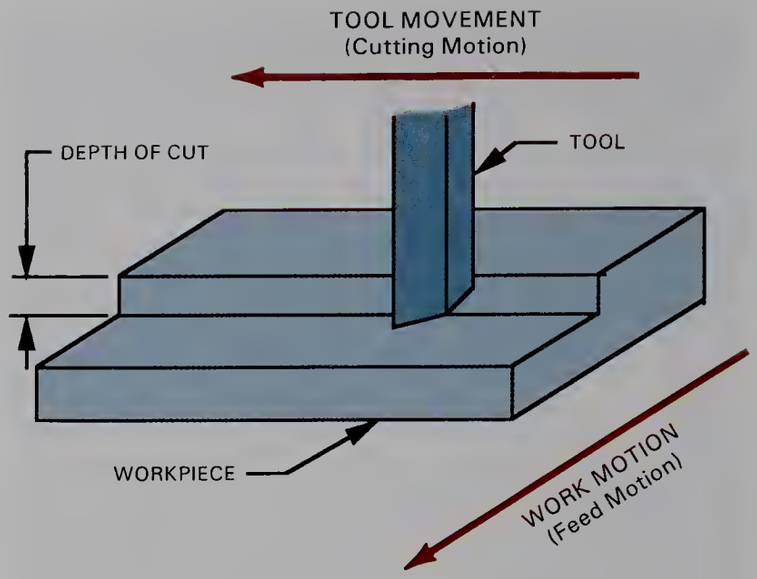


Fig. 9-15. This diagram shows the cutting and feed motions for a metal shaper. It cuts during the forward tool movement. The feed motion takes place as the tool is brought back (right) to the start of another cutting stroke.

Examples of specific machines that use each of these motions will be given later in this chapter. We will compare the basic separating machines in terms of the type of tools used, motions they generate, and the methods used to support the tools and the work.

Cutting speed is the rate of travel of the tool or workpiece during a cutting motion. In either case, the cutting speed is measured in feet per minute or meters per minute.

Feed motion

The movement that brings new material in contact with the cutting element is called **feed motion**. Feed motion is generally linear movement generated in each cycle of the cutting action. It is produced by

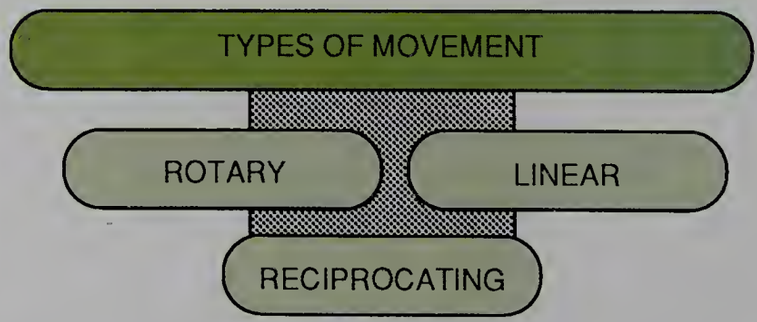


Fig. 9-16. These are the types of motion present in separating operations.

either moving the workpiece into the cutting element or moving the cutting element into the workpiece.

Feed is generally very slow when compared to the cutting motion. It is expressed in either inches or millimeters per revolution (for rotating movement), in inches or millimeters per stroke (for reciprocating movement), or in inches per foot (for linear movement).

To understand the difference between feed and cutting motions, carefully study the diagram of a band saw shown in Fig. 9-17. The blade moves downward to produce a linear cutting action. The chip is produced as a tooth passes through the workpiece. Think about this experiment. Suppose a band saw is not running. If you place a board against the blade and start the machine, the first tooth will produce a chip and remove some material as the blade moves downward. This is the cutting action, but the cutting action will stop here even though the saw blade continues to move. The remaining teeth will pass through the slot (kerf) the first tooth produced. However, if you move the board forward into the blade, new material will contact the teeth. Cutting action will continue. The movement of the board is the feed motion. Cutting takes place only when both cutting and feed motions are present.

Depth of cut

The amount of material separated from the workpiece in one stroke or revolution is the **depth of cut**, Fig. 9-15. It is the measured difference between the original surface and the new, machined surface.

The depth of cut is determined by the distance the cutter is fed into the workpiece or the distance the workpiece is fed into the cutter. In flat machining, the depth of cut and the reduction in the size of a material is equal. However, in rotating work operations, such as lathe turning, the reduction in the diameter of the work is twice the depth of cut.

Depth of cut is generally measured in thousandths (1/1000) of an inch for precision machining. Measurements are in fractions of an inch, however, for construction and woodworking processes.

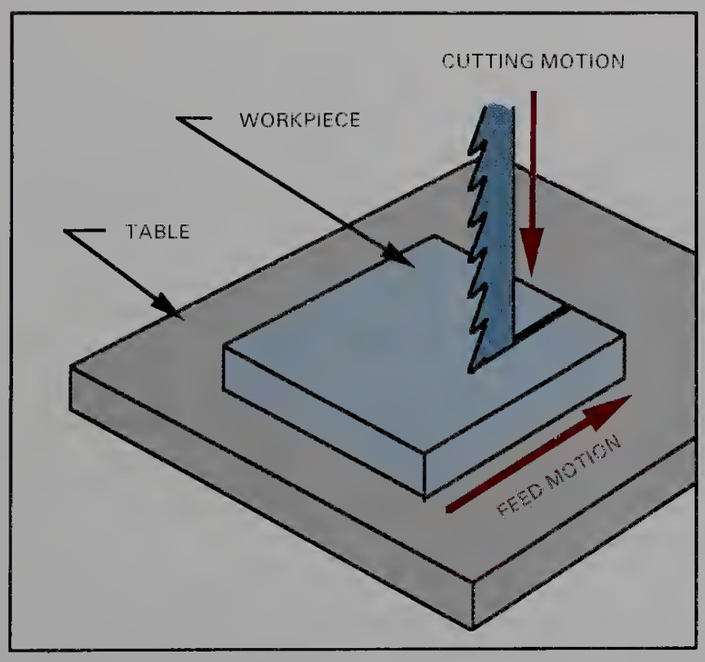


Fig. 9-17. This diagram shows the cutting motion for a band saw in linear (downward) movement of the blade. The feed motion is linear movement (horizontal) of the workpiece.

CLAMPING DEVICES

Most separating operations use machines that hold or support both the tool or cutter and the workpiece. These are **clamping devices**. The type of clamping device used is directly dependent on the feed and cutting motions used.

The type of cutting motion must be considered in selecting clamping devices for both the tool and the workpiece. Rotating work and tools must be gripped and turned. *Chucks*, such as drill chucks and router collets answer this need. Revolving cutters may be placed on shafts called *arbors*. Milling machines and grinders use this type of holding system. Finally, rotating workpieces can be supported between centers in lathes and cylindrical grinders.

Vises, clamps, and magnetic tables hold down the workpiece for flat, reciprocating, or stationary work. Work that is fed linearly is often clamped to a table or held in a machine vise. The table is then moved by gearing or hydraulic systems to provide feed motion. Woodworking operations often use guides (miter gauges and rip fences) so the work can be fed by hand.

You will see examples of all these clamping techniques in the next section of this chapter. Pay special attention to this feature in the figures that illustrate these separating operations.

SEPARATING MACHINES

Six basic machines separate materials. These machines, as shown in Fig. 9-18, are:

- Turning machines.
- Drilling machines.
- Milling and sawing machines.
- Shaping and planing machines.
- Grinding and abrasive machines.
- Shearing machines.

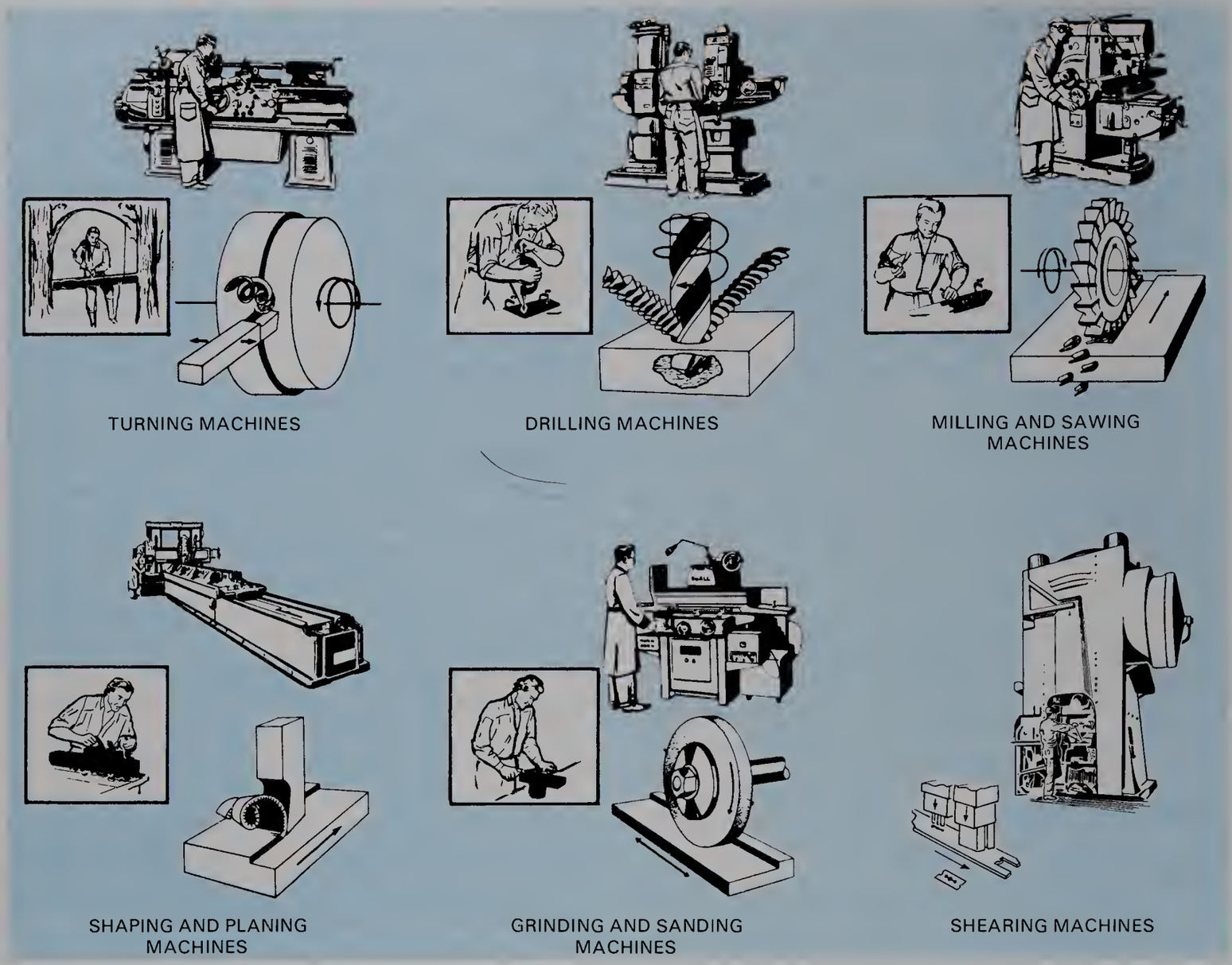


Fig. 9-18. These are six basic machine tools. (DoAll Co.)

In addition, there are separating machines and equipment that perform nontraditional machining. These machines also perform flame cutting.

TURNING MACHINES

Turning machines are almost as old as civilization itself. An early predecessor of this machine is the hand- or foot-operated potter's wheel. See Fig. 9-19. Clay placed on the flat potter's wheel was rotated. As the clay rotated, the potter shaped the material using his or her hands. Vessels and other ceramic objects were produced using this machine. From this early start, came our modern turning machines that are generally called lathes.

A large number of processes are completed on turning machines. However, these machines can complete two unique operations. These operations, as shown in Fig. 9-20, are straight turning and face turning. The work rotates to generate the cutting motion, Fig. 9-21. A single-point tool is fed into and along the work. This action establishes the depth of cut, and produces the feed motion. The work may be held between centers, as shown in Fig. 9-21, or in a chuck, as shown in Fig. 9-22.

Straight turning is performed on the external surface of a shaft and reduces the diameter of a material. The operation is performed by feeding the tool into the stock to establish the depth of cut. The tool is then moved along the length of the shaft parallel to its axis. This action produces a uniform diameter along the length of the part.

A modification of straight turning is **taper turning**. This operation produces a straight cut, but the diameter uniformly changes along the length of the part. This can be seen in Fig. 9-20. Taper turning uses a straight tool path that is not parallel to the axis of the shaft.



Fig. 9-19. Turning machines evolved from the potter's wheel.

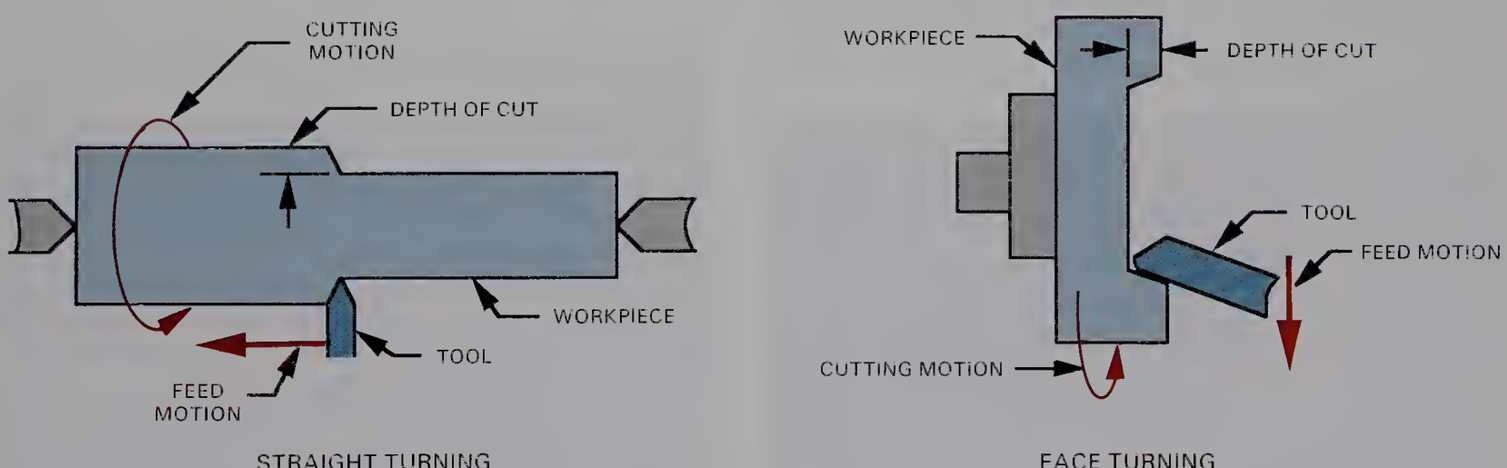


Fig. 9-20. There are two basic types of turning.

Face turning produces a straight cut across the face or end of a piece of material. The material can be round or rectangular. It is generally held in a chuck.

Special operations can also be completed on lathes. These include drilling and reaming holes, cutting threads inside holes and along shafts, and cutting grooves and angles.

Many types of turning machines can be used to machine metals. These include the engine lathe, turret lathes, automatic bar machines, and turning

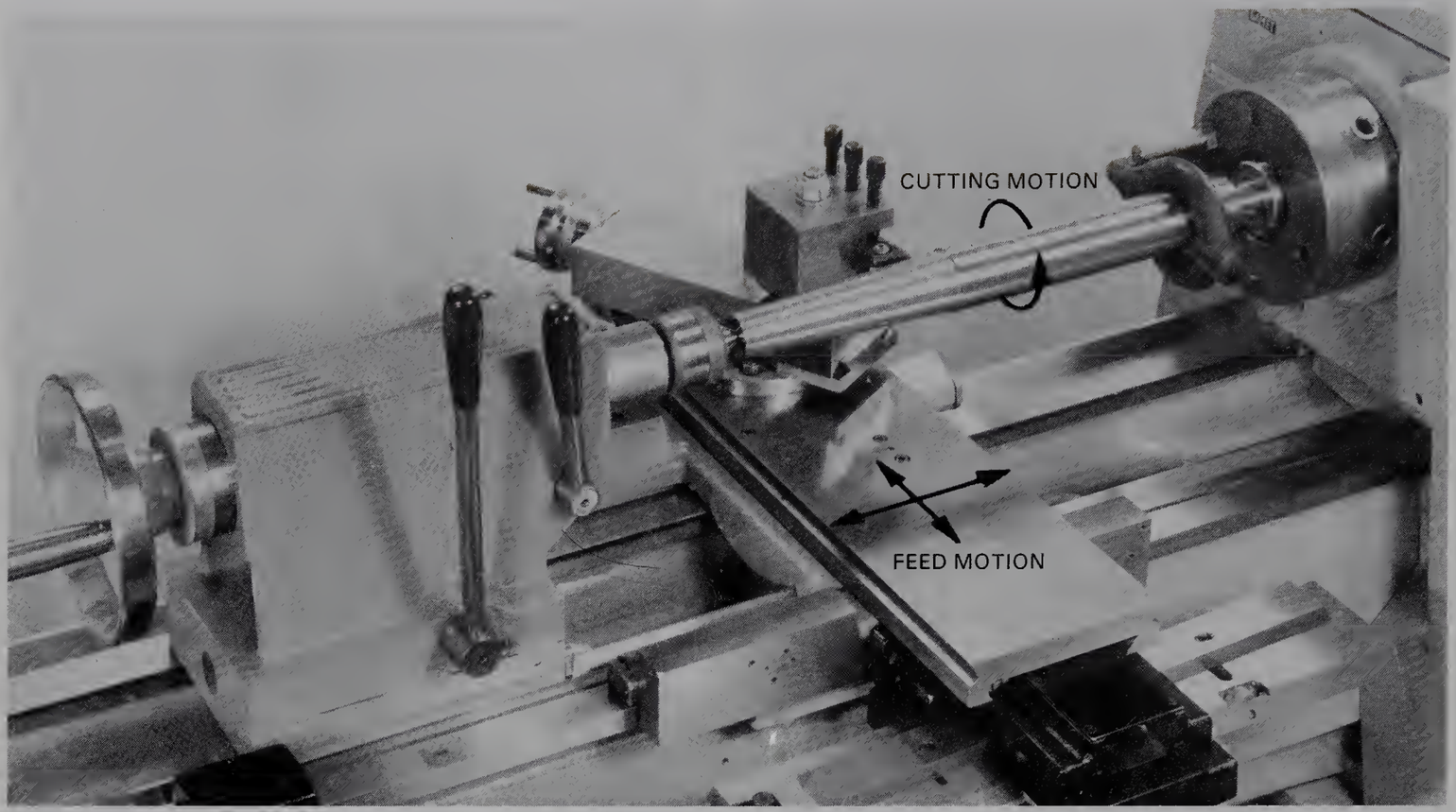


Fig. 9-21. A taper is being turned on this shaft that is being held between centers. Notice the cutting and feed motions. (Clausing)

centers. Other lathes can be used to machine woods and spin metals (a forming process).

DRILLING MACHINES

The first drills were produced about 40,000 years ago. A small, pointed stone was probably attached to a stick. This "drill" was rotated between the palms of both hands to cut a hole in a soft material. This same cutting principle is found in modern drilling machines, Fig. 9-23.

Drilling machines include drill presses (hole drilling), boring (hole diameter truing) machines, and tapping (thread cutting) machines. Simple drilling tools found in many home workshops might include the woodworking brace and auger bit, the hand drill

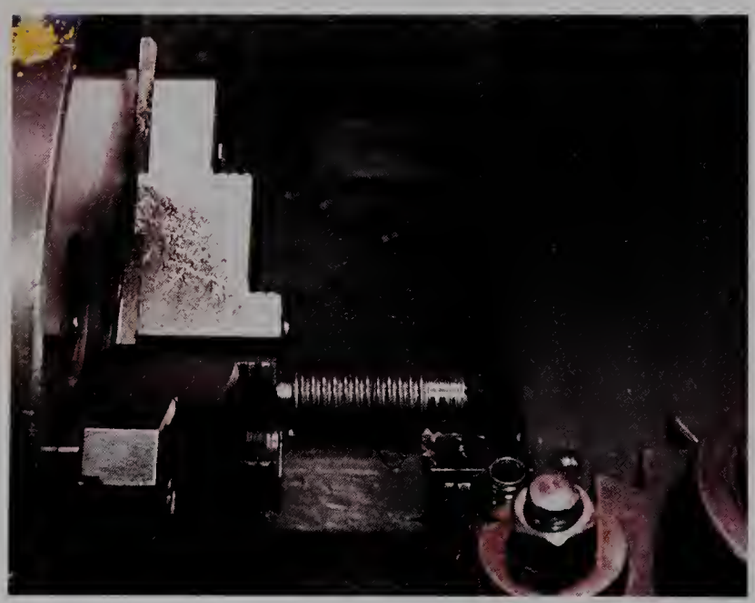


Fig. 9-22. This piece of stock is being held in a chuck on a lathe. (Inland Steel Co.)



Fig. 9-23. This drill press is being used to cut threads. (Inland Steel Co.)

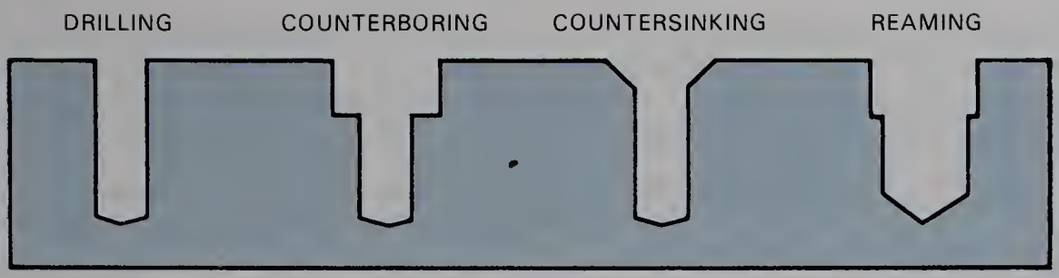


Fig. 9-24. These are common operations performed with a drilling machine.

and twist drill, and the portable electric drill with a drill bit.

Several operations can be completed on drilling machines. These, as shown in Fig. 9-24, include:

- Drilling.
- Counterboring.
- Countersinking.
- Reaming.

Drilling produces a straight, round hole in a workpiece. These holes can accommodate shafts and mechanical fasteners (screws, bolts, rivets, etc.).

Counterboring produces two holes around the same axis. The lower hole is smaller in diameter than the upper hole. Counterboring allows the head of a fastener to be set below the surface or it may seat a part with a shoulder.

Countersinking produces a bevel at the top of a hole. This is done to accommodate a flat head screw.

Reaming shapes or enlarges a hole. It is often used to widen an existing hole.

Drilling machines generally grip the cutting tool in a chuck. The tool, which may be a drill, reamer, or other bit, is rotated to generate the cutting motion. It is then moved downward (linearly) to produce the feed motion. The workpiece is held stationary on a table, clamped in a vise, or gripped in a special jig as shown in Fig. 9-25.



Fig. 9-25. This liquid oxygen fuel tank part for the space shuttle is being drilled in a special computer-controlled machining center. (Fansteel, Inc.)

MILLING AND SAWING MACHINES

People began using saws in early history. Archaeologists have found stone saws that date back about 7000 years. Later, saws were made from bronze and iron. The metal file, which works on the saw principle, was invented almost 2000 years ago.

All of these tools had one thing in common. They had regularly spaced teeth on a straight piece of material. As machines were developed, teeth were also shaped on the round pieces similar to the circular saw blades and milling machine cutters of today.

By observing cutting motion, you can place milling and sawing machines into three basic groups. As shown in Fig. 9-26, these machines generate their cutting motion by one of the following:

- Rotating the cutter.
- Moving the blade linearly.
- Producing a reciprocating blade motion.

Rotating cutting machines

The largest group of sawing machines separates material by rotating the cutter on a shaft. This action produces the cutting motion. These machines produce their feed motion by moving the stock linearly

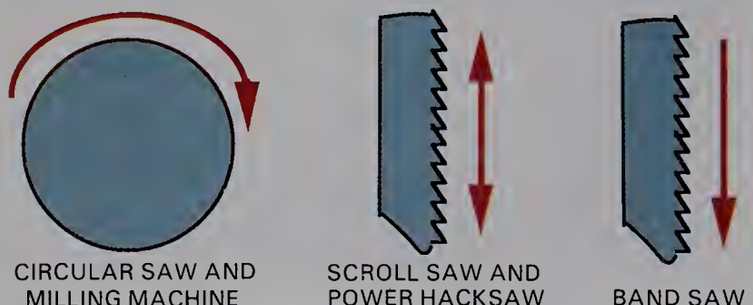


Fig. 9-26. This diagram shows cutting motions for sawing and milling machines.

into the cutter or blade. This feed motion may be generated either by manually feeding the stock or by using automatic table feeds. The depth of cut in this group of machines is established by either raising or lowering the cutter or the table upon which the workpiece rides.

The two most common machines in this class are the **horizontal milling machine** for metalworking, Fig. 9-27, and the woodworking **circular saw**, Fig. 9-28. Observe the cutting and feed motion in these illustrations.

Variations on these machines are the radial saw and the cut-off saw. The *radial saw* is widely used to cut material to length on construction sites and in furniture and cabinet factories. Various *cut-off saws* are used to cut finish trim for buildings (motorized miter saw), metal to length (chop saw), and concrete block and brick.

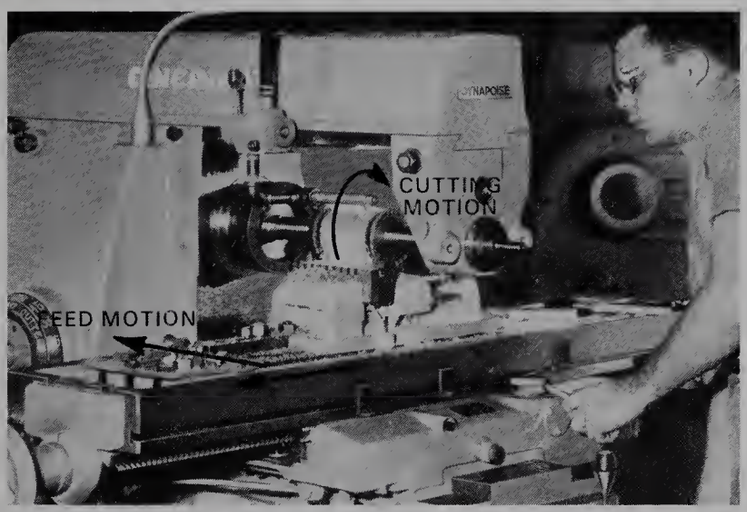


Fig. 9-27. This milling machine cuts a flat surface on a part that is held in a vise. (Cincinnati Milacron Inc.)

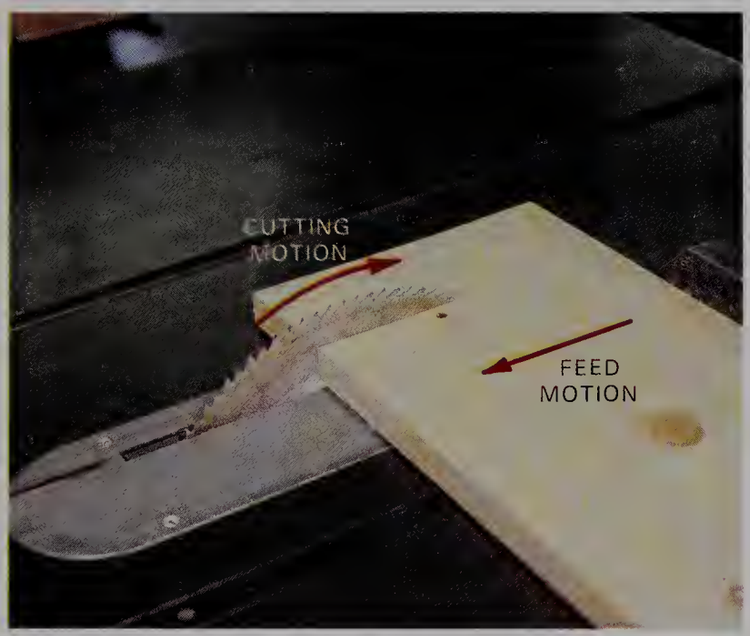


Fig. 9-28. The wood workpiece is being guided with a miter gauge through a rotating saw blade.

Both of these machines have a rotating saw blade that generates the cutting motion. However, the work is stationary while the blade moves linearly downward or outward to produce the feed motion. See Fig. 9-29.

Other machines that operate on milling principles are the woodworking jointer, shaper, surfacer, and router. Each of these machines has a rotating cutter that produces the cutting motion. The stock moves in a straight line past the cutter to develop the feed motion.

Other sawing machines

Power hacksaws and band saws are important saws that do not use rotary cutters. The blade is a strip of steel with teeth on one edge. The hacksaw uses a reciprocating motion with the cutting action taking place on the forward stroke. The feed motion of power hacksaws is similar to the cut-off saw. The saw unit is fed downward to produce the feed motion.

The band saw blade is a thin steel band that travels around two wheels. Standard *band saws* expose the right side of the loop where it passes through the table, Fig 9-30. The work is placed on the table and fed linearly into the blade. The standard band saw is used to cut curves and arcs in wood products, plastic sheets, as well as metal plates and sheets.

The *horizontal band saw*, like the vertical band saw, has a linear cutting motion. However, the stock to be cut is clamped in a vise. The blade unit is fed downward, like the cut-off saw, to produce the feed motion. Horizontal band saws are widely used to cut metal bars, rods, and structural shapes to length.

SHAPING AND PLANING MACHINES

The principle of shaping and planing is found in the old hand woodworking planes. Early carpenters

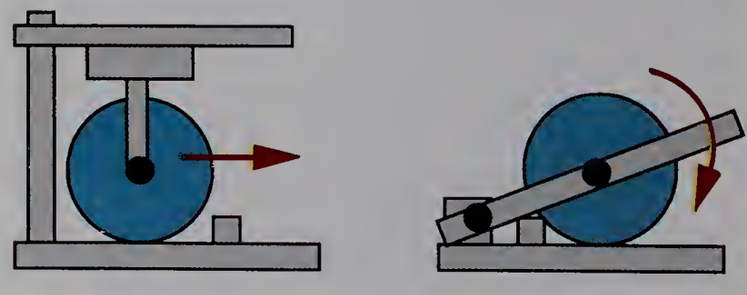


Fig. 9-29. Feed motion for radial and cut off saws is shown in these diagrams.

used blocks of wood and an iron blade to shape parts. These tools are still found in antique shops and museums. The plane was moved forward to make a cut then backwards to position it for the next cut.

The **metal shaper**, Fig. 9-31, cuts material by moving a single point cutting tool back and forth across a stationary workpiece. The work is clamped in a vise and positioned in front of the tool. A ram pushes the tool forward and through the material. The tool cuts on the forward stroke. On the backstroke, the tool pivots up and the work moves over (feed motion) for the next cut.

The **metal planer**, shown in Fig. 9-32, uses a reciprocating workpiece to develop the cutting motion. The single point tool can cut on the forward stroke of the work or on both the forward and backward strokes. The work is clamped on the planer table. The tool is positioned over the work for the first cut. The table travels under the tool to produce the chip. The tool moves over for a new cutting path at the end of the cutting stroke.

Metal shapers are generally smaller than planers. Both machines are only of limited use in modern industry.

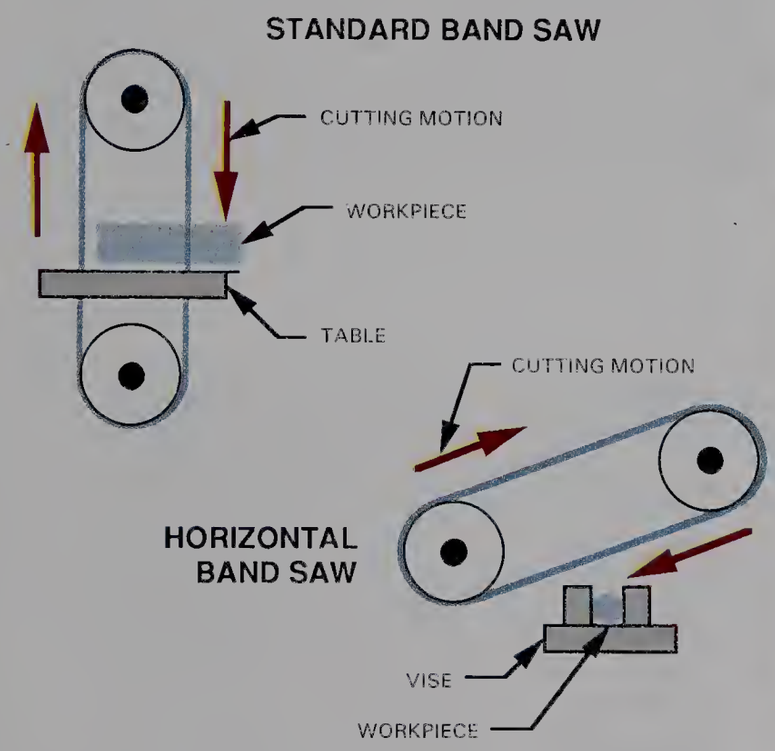


Fig. 9-30. These are common types of band saws.

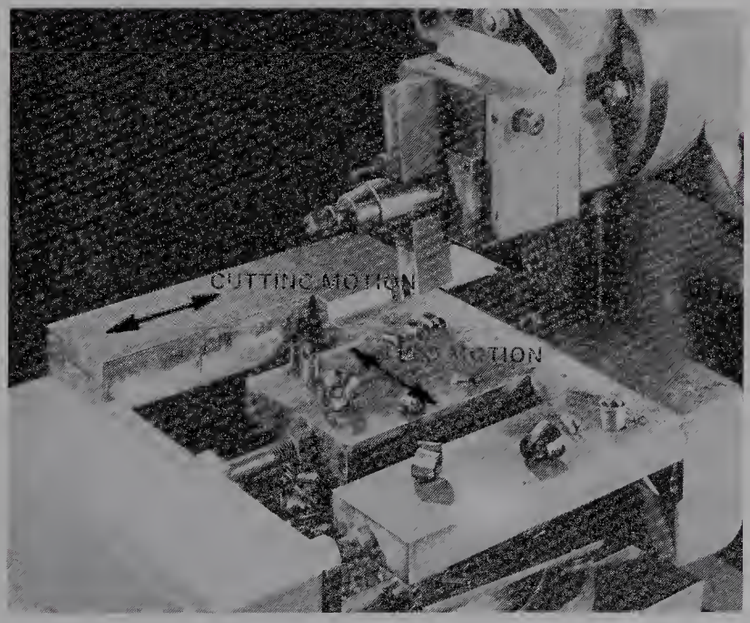


Fig. 9-31. A standard metal-cutting shaper separates material with a single point tool passing across the flat workpiece. (Rockford Machine Tool Co.)



Fig. 9-32. This twin head metal shaper cuts on both the forward and back passes. The workpiece moves, while the tool is stationary during the cutting act. (Inland Steel Co.)

GRINDING AND ABRASIVE MACHINES

Our ancestors found that sharp edges could be formed by rubbing a strip of metal over a hard, rough material. As early as 1500 B.C., this practice was in general use. **Abrasive machining** has developed from this early separating technique. These machines are used for grinding and sanding operations that remove excess material. They also create smooth surfaces where needed.

Unlike the other types of machines discussed so far, grinding machines do not have specific cutting and feed motions. They are adaptions of other machine tools. What is common among these machines is their use of a natural or human-made abrasive

grain. The material is bonded to a wheel or adhered (glued) to a flat paper or cloth backing material.

Abrasive wheels are used on several types of grinding machines Two of these machines are cylindrical grinders and surface grinders.

In principle, *cylindrical grinders* are very much like lathes, Fig. 9-33. They hold and rotate the workpiece in a chuck or between centers. The rotating grinding wheel is fed into the work to generate the chip. The feed motion is produced by moving the work and its holder that is attached to a table. The distance the wheel is fed into the work establishes the depth of cut.

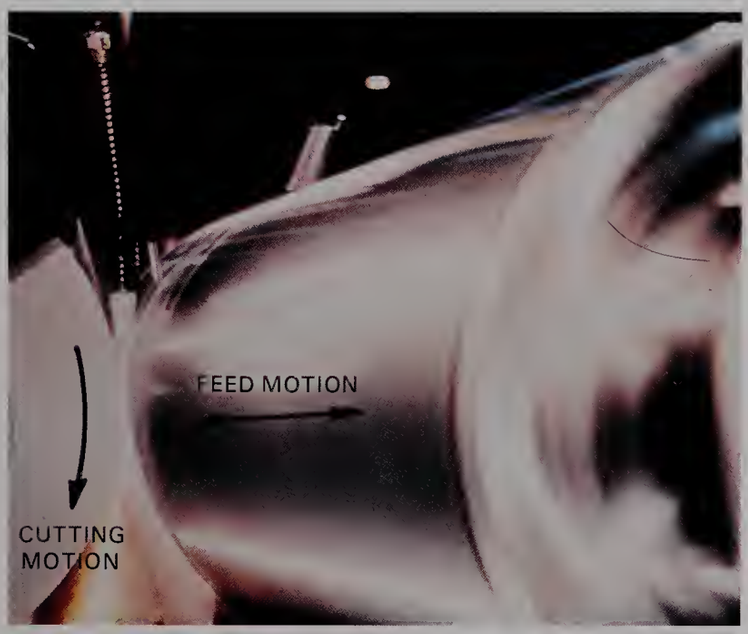


Fig. 9-33. The cylindrical grinder is similar to the lathe in appearance and cutting action.

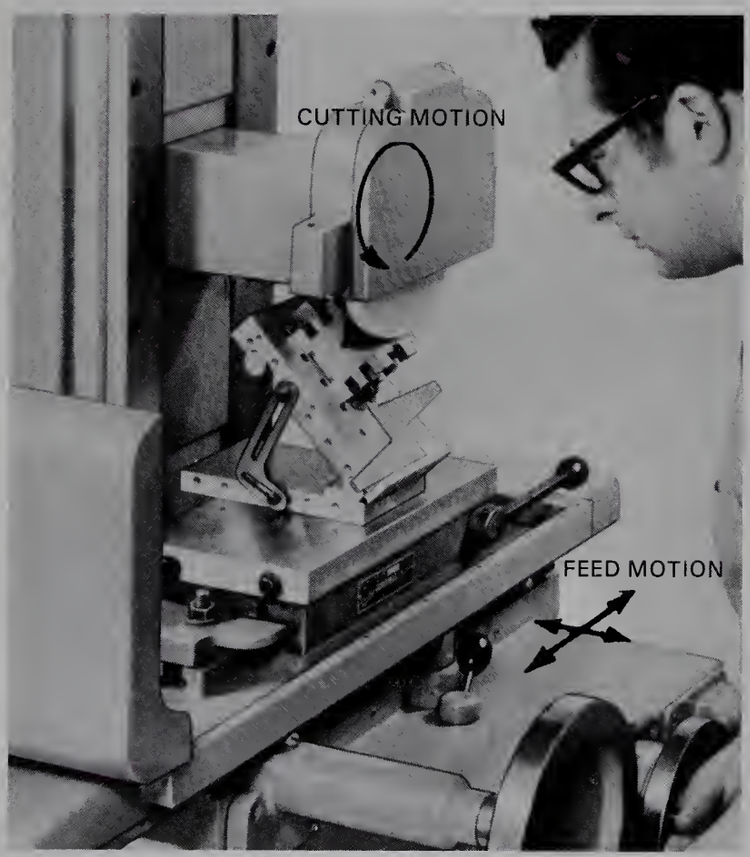


Fig. 9-34. The cylindrical grinder uses a rotating grinding wheel and a moving table much like a milling machine.

The *surface grinder* works on the milling machine principle, Fig. 9-34. The workpiece is held on the machine table with bolts, clamping fixtures, or magnetic force. The rotating grinding wheel produces the cutting action. The work is reciprocated under the rotating grinding wheel to produce the feed motion.

Machines that use flat abrasives are called *sanders*. These machines can use abrasive sheets, discs, or belts to sand and polish metals, woods, ceramics, and plastics.

The *disc sander*, as shown in Fig. 9-35, operates like a milling machine. An abrasive sheet is attached to the machine's metal disc. This assembly forms a random, multipoint cutting tool. The work is fed into the revolving disc to produce the cut. Portable disc sanders, like the one shown in Fig. 9-36, are often used to clean machines and cast parts.

The *belt sander* uses abrasives glued to a continuous band of material, Fig. 9-37. Its cutting principles are similar to the band saw. The abrasive travels horizontally or vertically past the work to generate the cutting motion. The work is fed linearly into the belt to produce the feed motion.

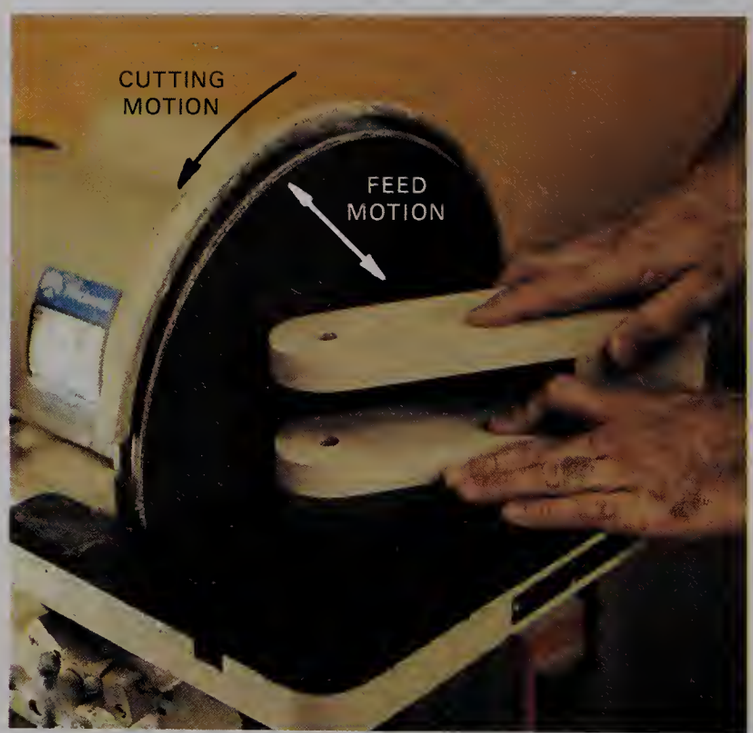


Fig. 9-35. The disc sander, like the milling machine, uses a rotating cutter into which material is fed. (Delta International Manufacturing Co.)



Fig. 9-36. This worker is using a pneumatic-operated sander to touch up a fiberglass truck cab component. (ARO Inc.)



Fig. 9-37. This belt sander uses a fast moving abrasive belt to cut away unwanted material.

SHEARING MACHINES

The shearing machine is a major type of separating equipment. While other machines force tools against a workpiece to create a chip, **shearing machines** use two opposed edges to fracture or break the excess material from the workpiece. Shearing actions, unlike chip removal, do not lose materials. The length of the two parts will add up to the original length of the strip.

You have practiced shearing many times. Every time you cut paper or cloth with a pair of scissors, you are using a shearing technique.

Most shearing machines have a moving blade or die and a stationary edge. *Squaring shears*, Fig. 9-38, use two straight shearing blades to cut sheet metal to size. The upper blade moves downward to fracture the material over the lower blade.

Dies, like the one shown in Fig. 9-39, often produce a shaped hole or outline. The movable upper die is mated to a stationary lower die. The die halves are mounted in a punch press. The material between the die halves is sheared as the punch press closes. Vast quantities of sheet metal and plastic are cut to size and shaped using dies.

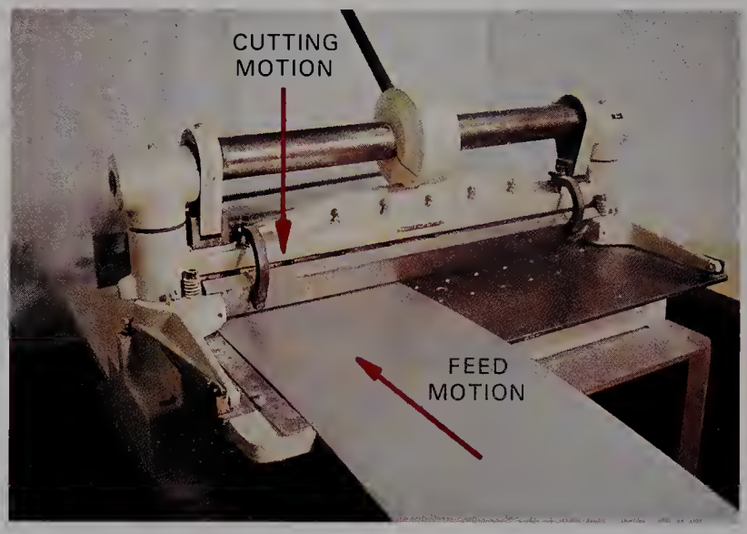


Fig. 9-38. This worker is using a squaring shear to cut metal strips to length.

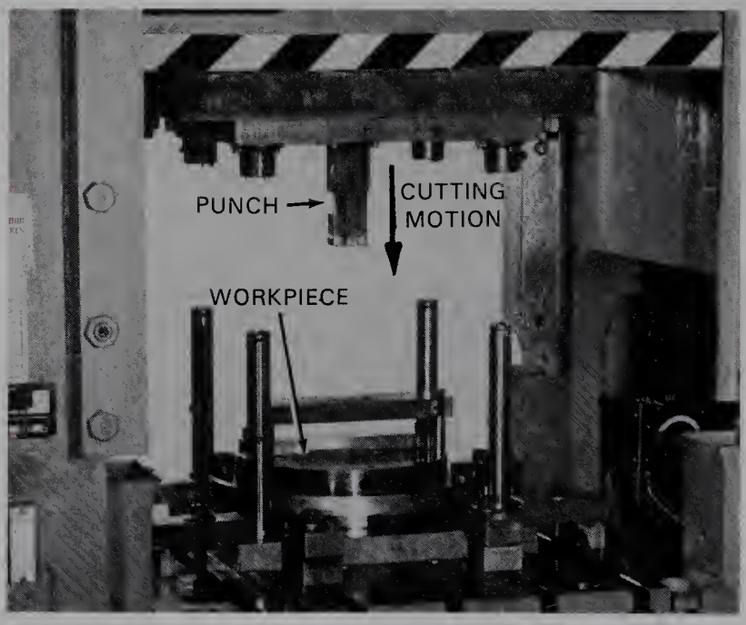


Fig. 9-39. Shearing dies are commonly used to produce irregularly shaped holes in sheet metal and plastics. (E. W. Bliss Co.)

OTHER SEPARATING EQUIPMENT

Nontraditional separating methods use special purpose machines such as those discussed earlier. Flame cutting is often done with oxyacetylene equipment similar to that which will be introduced in Chapter 11.

SUMMARY

Separating processes are widely used in industry to size and shape metal, wood, ceramic, and plastic materials. The separation action is accomplished through the use of tools and forces generated by a combination of cutting and feed motions.

Hundreds of separating machines have been developed and used over time. These machines can best be understood if they are viewed in terms of:

- The type of tool used.
- The of movement used to generate the cutting and feed motions.
- Methods used to clamp the work and tool.

Separating actions can be grouped into two categories: machining and shearing. Machining sizes and shapes material by removing excess materials in the form of chips or small particles. Shearing fractures the excess material away from the workpiece.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

abrasive machining
chemical machining
circular saw
clamping devices
counterboring
countersinking
cutting elements
cutting motion
depth of cut
drilling
electrical discharge grinding (EDG)
electrical discharge machining (EDM)
electrical discharge sawing (EDS)
electrical discharge wire cutting (EDWC)
face turning
feed motion
flame cutting
horizontal milling machine
laser beam machining (LBM)
linear
machining
metal planer
metal shaper
multiple point tools
rake
reaming
reciprocate
relief angles
rotate
shearing
shearing machines
single point tools
straight turning
taper turning

TEST YOUR KNOWLEDGE

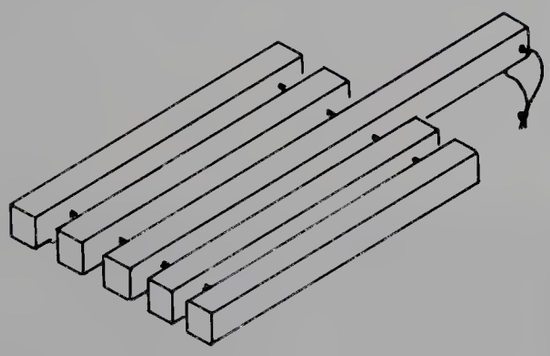
(Please do not write in this text. Place your answers on a separate sheet.)

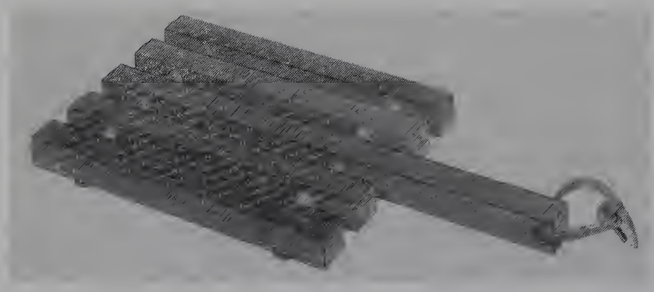
1. What is the difference between machining and shearing?
2. True or False? One of the earliest power-driven metal-cutting machines was the lathe.
3. List the three essential elements of separating.
4. Name six basic machines that have been developed to separate materials.
5. True or False? Face turning is performed on the external surface of a shaft and reduces the diameter of a material.
6. Which of the following produces a straight, round hole in a workpiece?
   a. Countersinking.
   b. Drilling.
   c. Counterboring.
   d. Reaming.
7. List the three ways milling and sawing machines can generate their cutting motion.
8. True or False? Metal shapers and planers are used extensively in modern industry.
9. Abrasive machines are used for:
   a. Sanding operations that remove excess material.
   b. Creating smooth surfaces.
   c. Grinding operations that remove excess material.
   d. All of the above.
10. While other machines force tools against a workpiece to create a chip, _____ machines use two opposed edges to fracture or break the excess material from the workpiece.

APPLYING YOUR KNOWLEDGE

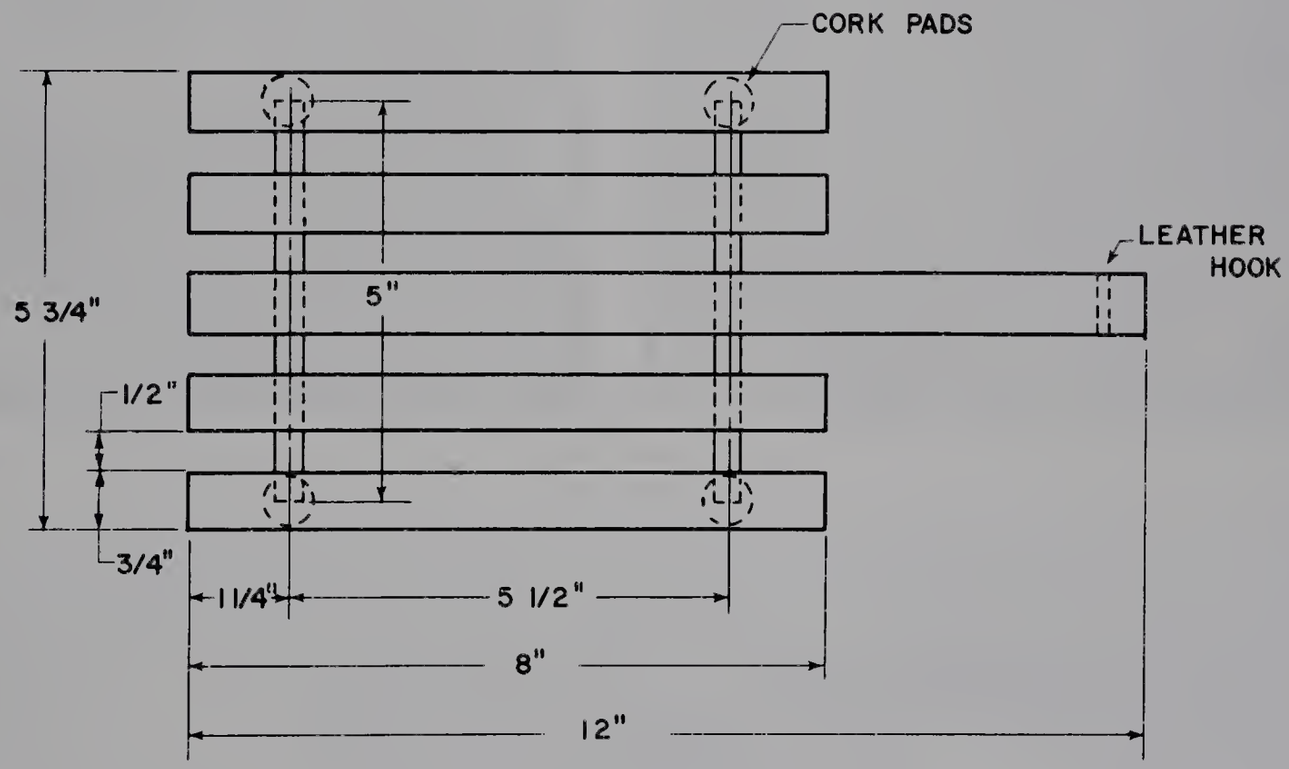
Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Manufacture a part or product using common separating processes. This might include a simple box for the injected molded checkers you made during the forming activity or a hot dish holder (trivet), as shown in Fig. 9-A.
   a. If you decide to manufacture the box for the checkers, produce a design. (Be sure to survey your laboratory equipment to make certain you can produce the product you design with the equipment available.
   b. Develop a procedure for making the box. Discuss the procedural steps with your instructor.
   c. Collect the materials needed.





HOT DISH HOLDER -- TRIVET



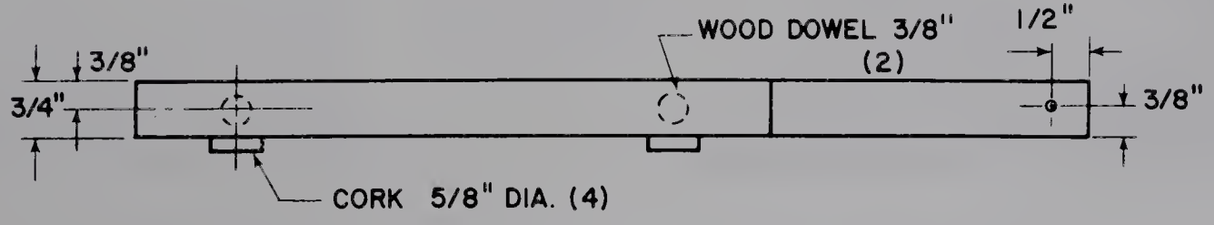


Fig. 9-A. Several separating processes are involved in producing this hot dish holder (trivet). Can you name them?

d. Secure the tools and begin the activity.
e. If you decide to build the trivet instead, you can omit the design phase unless you wish to modify the design.
f. See your instructor. He or she may suggest procedures or have you develop them.

2. List all the ways you use separating actions during one day of normal activities at home and at school. Describe each action in terms of the tool or machine used, the type of cutting element, and the material separated.
3. Analyze a simple product and make a list of the separating actions that were needed to produce the product.
4. Observe the cutting action of three machines in the technology education laboratory. Analyze them in terms of the type of cutter, the methods used to generate the cutting, and feed motions.





Look at these two machines. Can you name them and identify the type of tool, cutting motion, and feed motion being used?

10

CHAPTER

CONDITIONING PROCESSES

After studying this chapter, you will be able to:

- *Describe how heat, mechanical force, or chemical action can be used to condition materials.*
- *List reasons materials are conditioned.*
- *Name and describe six common thermal conditioning practices.*
- *Give examples of how chemical conditioning is used.*
- *Explain mechanical conditioning and how it occurs.*

In the last three chapters, you learned about processes that give parts their size and shape. These processes change the external appearance of the material. You will recall that in casting processes, the material receives a new size and shape by melting and pouring it into a mold. As materials go through forming processes, a shaping device is used to apply pressure to reshape the material. Separating processes remove excess material to size and shape a part. In many cases, these processes do not produce a totally usable part.

Sometimes, changing the outward, physical properties of a material is not enough. Often, the mechanical properties of a material must also be changed. In order to be suitable for a specific task or use, the strength, toughness, hardness, elasticity, or other mechanical properties of a material may need to be improved. See Fig. 10-1.

Processes that use heat, mechanical force, or chemical action to change the mechanical properties of a material are called *conditioning processes*. In

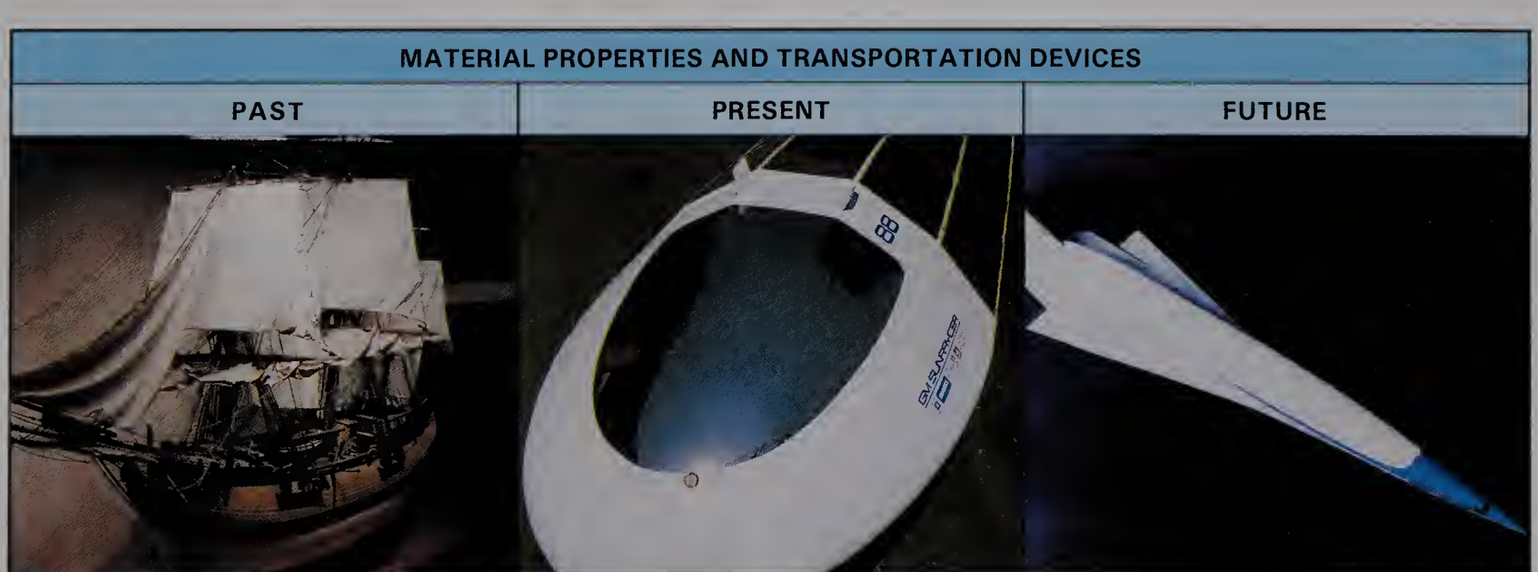


Fig. 10-1. Look at these transportation devices. What material properties do you think were considered in designing: Left–The sailing ship? Center–The frame for the Sunraycer solar-powered car? (General Motors Corp.) Right–The hypersonic aircraft? (NASA)

selecting and using conditioning processes, several factors must be considered. These, as shown in Fig. 10-2, are that:

- The desired mechanical property must be established.
- The internal structure that produces this property must be determined.
- The procedure that will develop this structure must be selected.

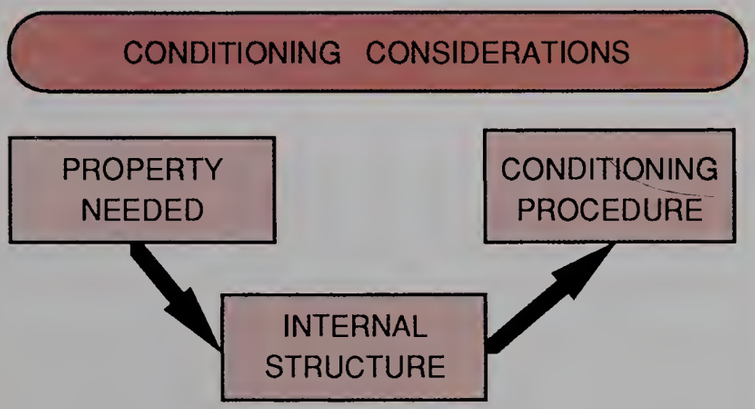


Fig. 10-2. Certain considerations must be made before choosing a conditioning process.

MECHANICAL PROPERTIES OF MATERIALS

The first step in selecting a conditioning process is to determine the appropriateness of a material for a job. The material must be matched to the conditions under which it must function. Each of its many properties must be compared to the operating conditions. This will insure that the product produced from the material will operate in the environment. It must also perform its task successfully.

In Chapter 4, you learned that all materials have a number of specific properties that can be grouped into seven categories: physical, mechanical, chemical, thermal, electrical and magnetic, acoustical, and optical. Some of the specific properties under each of these categories are listed in Fig. 10-3.

Conditioning processes primarily deal with mechanical properties. These are the properties that resist mechanical forces or load. The major mechanical forces are:

- *Compression*: This is the force that squeezes or crushes a material.
- *Tension*: This is the force that pulls or tears a material apart.
- *Torsion*: This is the force that twists a material around an axis.
- *Shear*: This is the force where opposing forces fracture a material along a plane.

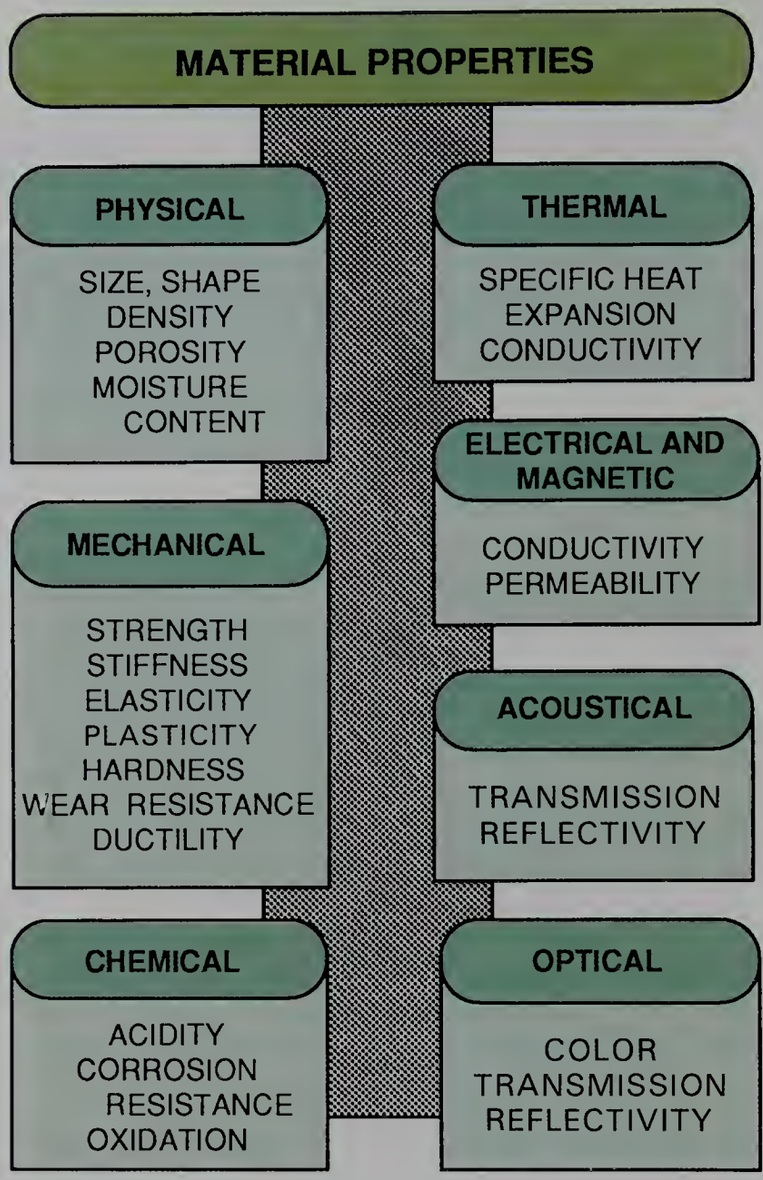


Fig. 10-3. Properties of materials determine the choice of conditioning processes.

The strength of materials is measured by the amount of force needed to break or rupture them. Parts that need to withstand any or all of these forces must be strong. Chains, tractor hitches, and engine parts are examples of items that must have high strength.

Other mechanical properties include hardness, softness, ductility, brittleness, elasticity, and stiffness. Some of these properties can also be changed through conditioning.

A material is considered to be hard if it resists denting and scratching. *Hardness* is important for parts that will be subjected to friction or wear (rubbing, turning, or sliding). Bearings that fit around shafts and allow them to turn more freely must be very hard. Conditioning prepares them for this task. Likewise, cutting tools must be hard.

The opposite of hardness is *softness*. Soft materials will scratch and dent easily. Most solid wood

products are considered to be soft. This quality allows wood to be easily cut and sanded.

Another important mechanical property is *ductility*. A material is ductile if it can be deformed (bent, compressed, or stretched) to a considerable extent without breaking. At the same time, the material must hold a fairly heavy load while being deformed. For instance, chewing gum would not be considered ductile even though it can be drawn out. It cannot hold up to a load. Ductility allows materials to be bent, drawn into wire, and formed using various mated dies. Generally, the harder a material is made, the less ductile it becomes.

Nonductile materials are described as *brittle*. A brittle material breaks with little or no elongation (stretching). Glass and many clay (ceramic) products are considered to be brittle.

Elasticity is the ability of a material to be deformed and return to its original shape when the force is removed. An elastic material can be flexed (stretched) many times without changing its shape. Elasticity is an important property for springs, vehicle tires, and basketballs.

Stiffness is the mechanical property that describes a material that resists being flexed or bent. This property is needed in diving boards, archery bows, and knife blades.

STRUCTURE AND MATERIAL PROPERTIES

The specific mechanical properties a material exhibits are a direct result of its physical structure. Metals form crystal structures when they cool. The structure of wood is determined by genetic factors and growing conditions. Ceramic materials are complex, crystalline structures. Composite materials are composed of a filler in a matrix. Unique structures account for many of the differences among these groups of materials.

The properties of a material can be altered only if the structure is changed. Therefore, once the desired property is established, the structure that will provide this property must be determined. A conditioning process is then selected to develop the appropriate structure.

TYPES OF CONDITIONING PROCESSES

Materials are conditioned for a number of reasons. The most important of these are to:

- Make materials easier to form or separate.
- Remove internal stress that has built up during casting, forming, separating, and assembling processes.
- Develop specific mechanical properties.

Changes in internal structure may be developed by several types of processes. These, as shown in Fig. 10-4, are thermal (heat) conditioning, chemical conditioning, and mechanical conditioning.

THERMAL CONDITIONING

Thermal conditioning changes the internal structure of materials through controlled heating and cooling. These processes can be used to change the hardness of a material, remove internal stress, or change the moisture content.

The most common thermal conditioning practices, as shown in Fig. 10-5, are:

- **Hardening:** This is a process used to increase the hardness of a material.
- **Annealing:** This is a process used to soften and/or remove stress from a material.
- **Tempering:** This is a process used to relieve internal stress in a material, usually associated with hardening.
- **Drying:** This is a process used to reduce the moisture content of a material.

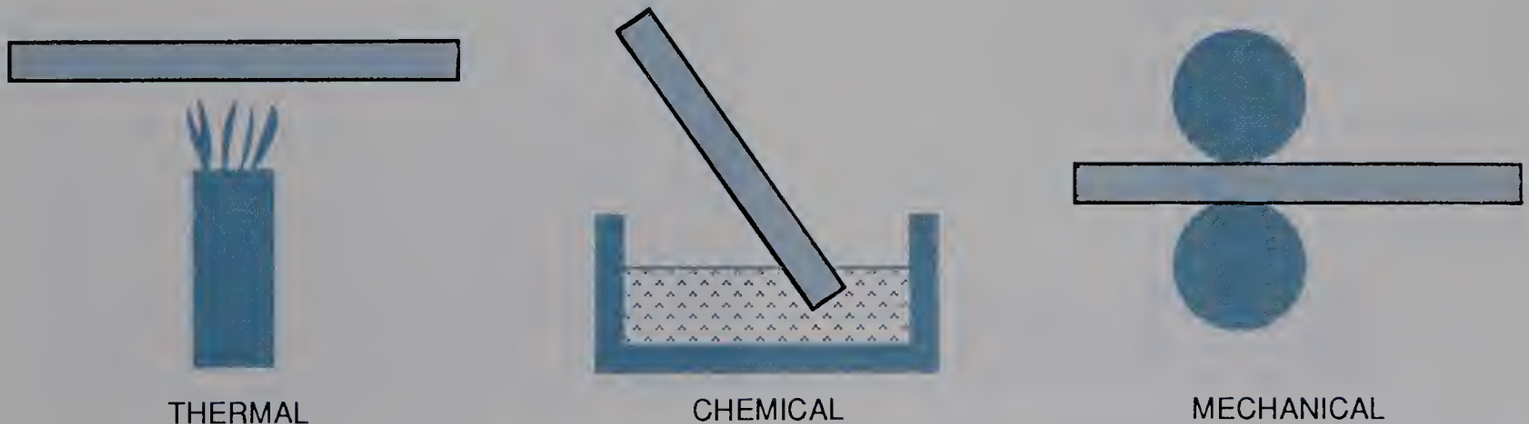


Fig. 10-4. These diagrams illustrate methods of conditioning materials.

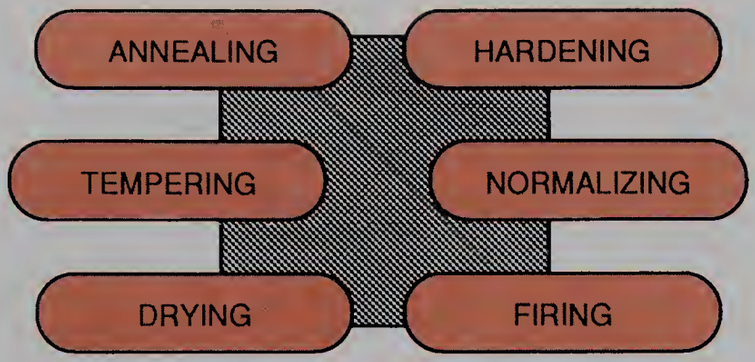


Fig. 10-5. These six thermal conditioning processes use heating and cooling to change the hardness of a material, remove internal stress, or change the moisture content.

- **Normalizing:** This is a process used to return steel to its pearlitic (normal) internal structure.
- **Firing:** This is a process used to increase the hardness of a ceramic material.

Thermal conditioning processes are used on woods, plastics, and metals. When applied to metals, the thermal conditioning processes are often called **heat-treating**.

Steels (iron alloys) lend themselves to the widest variety of heat treatments. The carbon content determines the condition of steel after it has been heat-treated. Generally, the higher the carbon content the harder a steel becomes under proper heat treatment.

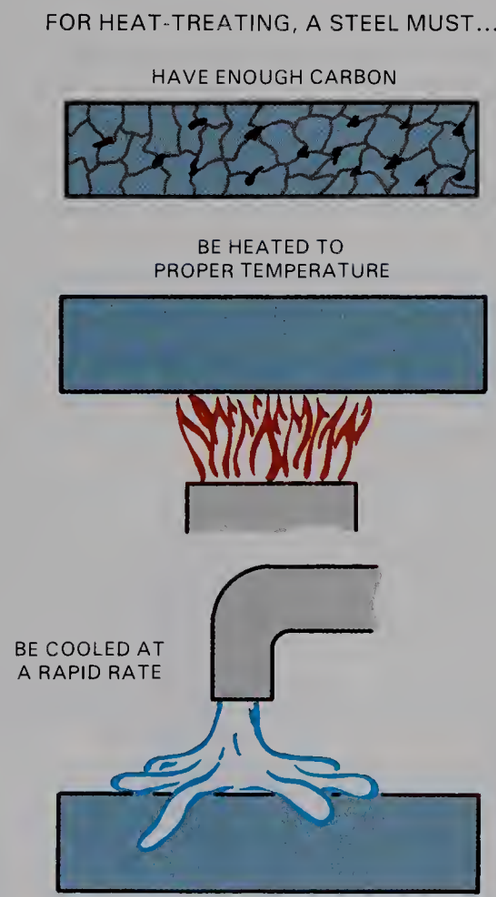


Fig. 10-6. In order for steel to be heat-treated, these conditions must exist.

All heat-treating processes produce one of two results. They either harden the metal or they soften it. Often, during hardening, internal stress is produced. Softening processes (annealing and tempering) reduce this internal stress.

For many applications, such as tools, bearing surfaces, and forming dies, steel must be made hard. Hardening steel, as shown in Fig. 10-6, requires that:

- The metal has sufficient carbon (0.80 to 1.50 percent). This steel is called *tool steel*.
- The metal is heated to the proper temperature (1400 to 1500°F or 760 to 816°C). The temperature varies with the carbon content of the steel.
- The metal is cooled rapidly. Oil or water quenches are used to insure uniform and rapid cooling.

In normal heat-treating, steel of proper carbon content is placed in a furnace, Fig 10-7. Here the metal is carefully heated to the correct temperature. It is then allowed to soak so that all portions of the material reach an established temperature. The part



Fig. 10-7. The hot parts (top) are leaving the heat-treating furnace. They will be ground to become machine rolls (bottom). (Bethlehem Steel Co.)

is removed from the furnace and quickly quenched in water or oil, Fig. 10-8. This rapid cooling sets the internal grain structure.

The process hardens the entire part and is, therefore, classified as a full-hardening process. It produces a fine-grained steel that is hard, very brittle, and has internal stresses. For this reason, after hardening, the steel receives additional heat-treating to remove these stresses. This processes is called tempering. In this stress-relieving process, the metal is heated to 600 to 1200°F (316 to 649°C). It is then allowed to cool slowly. The resulting part is somewhat less hard, but much less brittle.

Tempering is also used to relieve stress in glass products. The newly cast or formed glass is slowly cooled in an oven to reduce the internal stress. These stresses can cause the product to break unexpectedly, Fig. 10-9.

Additional metal hardening processes produce a hard surface. These processes are called *case-hardening* techniques. Carbon or nitrites are added to the surface of a mild steel workpiece. The part is then heated and quenched, producing a hard shell on a ductile core. The hard surface resists wear, while the soft core can absorb stress and strain.

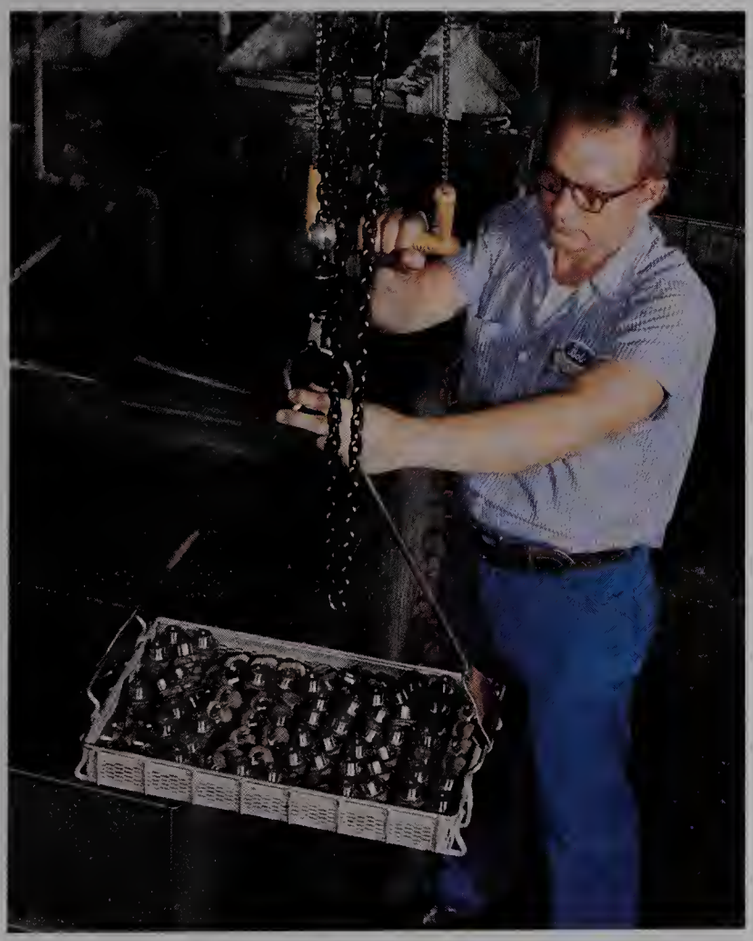


Fig. 10-8. These steel parts are being removed from a quench tank. (ARO Corp.)



Fig. 10-9. This ribbon of glass is entering a tempering line. (PPG Industrial)

Metals can be softened by a heat-treating process called annealing. Annealing removes the hardness from a part that has occurred during other processing activities or that has occurred as a result of heat-treating. In annealing, the metal is heated to a specific temperature. It is then allowed to soak so that a uniform material temperature is developed. The part is then allowed to cool slowly. Often, the material is covered with sand to insure a slow, uniform cooling cycle.

Normalizing is a softening technique that removes internal stresses. It is a process that is similar to annealing. The major difference is that the metal is heated to 100 to 200°F (38 to 94°C) above the annealing temperature. As the metal cools slowly, a fine grain structure is developed.

Not all thermal conditioning is restricted to metals. Heat is often used to harden ceramic materials in a process called firing.

The ceramic material to be fired contains clay and a glass-like material called flux. When the material is heated, the flux becomes a "cement" that melts and fuses into a hard, rigid structure.

Firing is often done in large kilns, Fig. 10-10. The kiln has several zones that are held at different temperatures. The first zone heats the product and removes excess moisture. The center, hot zone fires (bakes and fuses) the clay. The third zone allows the clay to cool slowly. In this zone, the internal stresses are removed.

Wood materials are also placed in kilns. They are heated slowly to remove excess moisture. When the wood cools, it is more stable and easier to work. Furniture, cabinets, and most homes are built with kiln-dried lumber.

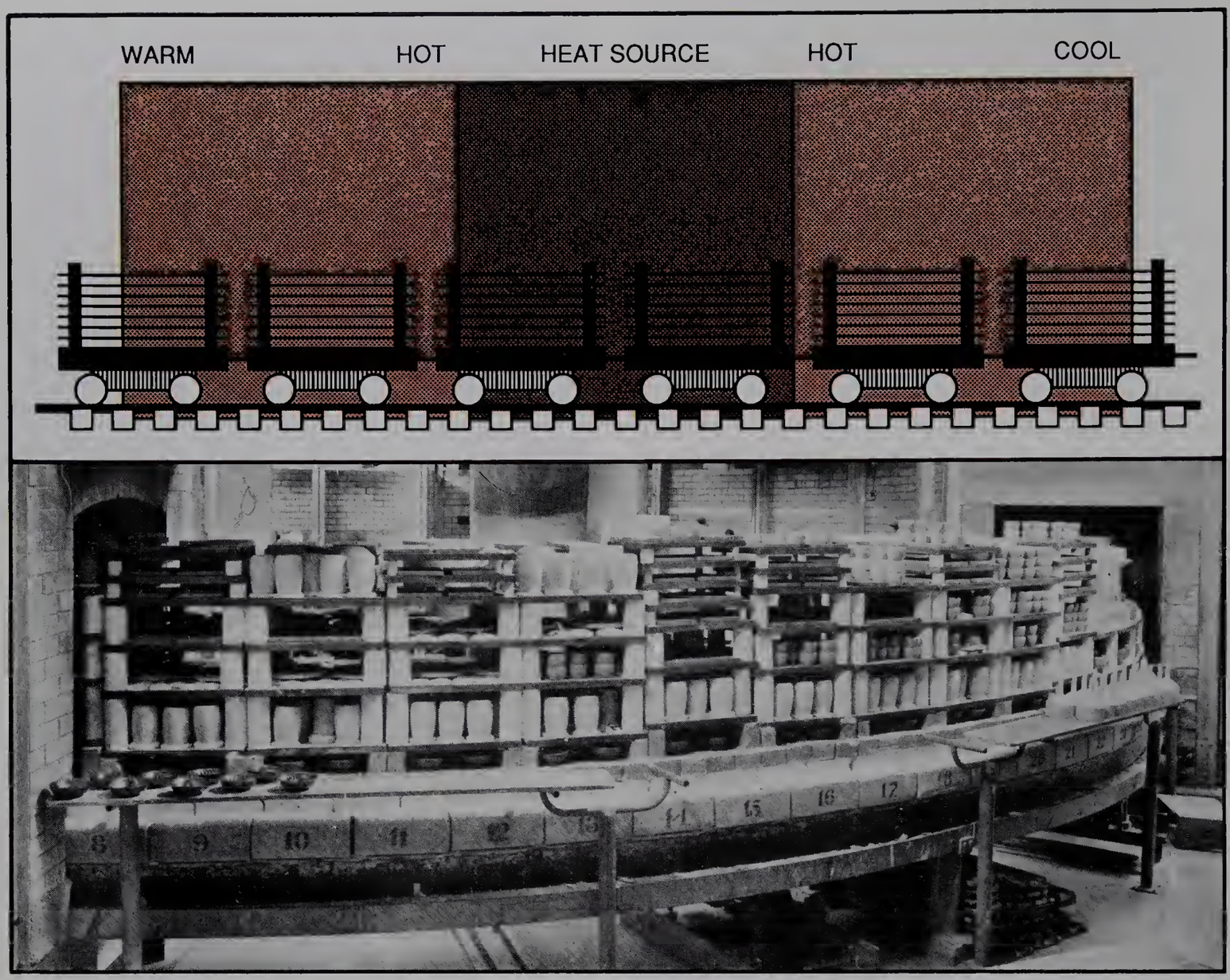


Fig. 10-10. Tunnel kilns, like the one diagramed (top), are used to fire ceramic products like the porcelain laboratory ware (bottom). (Coors Porcelain Co.)

CHEMICAL CONDITIONING

Internal properties of materials may be changed by chemical action. This is called **chemical conditioning**. A catalyst (material that starts a chemical action) may be added to a liquid plastic material. The molecules in the plastic undergo change. They link together to form longer, more rigid polymer chains. This action is called **polymerization**. The material is changed from a liquid to a solid.

This action is often used with plastic casting operations, Fig. 10-11. The result is a harder, more durable product. In many cases, a fracture-resistant material is added to the plastic to improve its usefulness and durability.

Glass lenses for eyeglasses are treated with chemicals to make them more fracture-resistant. This property is essential for safety glasses.

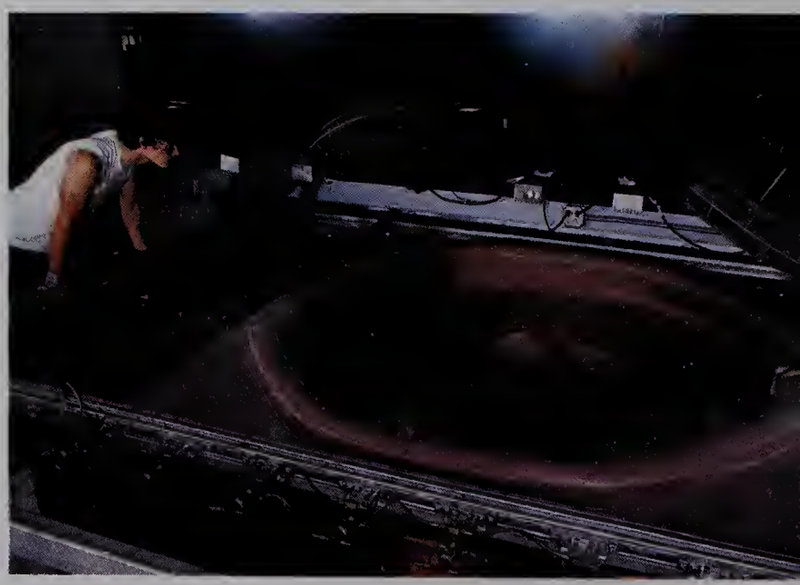


Fig. 10-11. The plastic material that binds the fiberglass in these hot tubs was hardened (set) by chemical action. (Rohm and Haas)

Animal hides are also chemically conditioned. They are treated with a series of chemicals during the tanning processes. The result is a material called leather.

MECHANICAL CONDITIONING

Mechanical force is sometimes used to condition materials. This is called **mechanical conditioning**. Often, this action is an unwanted result of other manufacturing processes. During cold-forming operations, the material is subjected to rolling and hammering forces, Fig. 10-12. These forces change the structure of ductile metals into long, closely packed grains of hard metal. This change is called **work-hardening**. Although this change is not primarily the purpose of forming and machining processes, it must be considered.

Shot peening is an intentional mechanical conditioning process. The process, as shown in Fig. 10-13, sprays small steel balls (shot) against parts. The action produces a series of small depressions (dents) in the metal. This increases the ability of the material to resist fatigue. Shot peening is widely used to condition springs. After shot peening, a spring can withstand a greater number of flexures (stretches) before it fails.

SUMMARY

Not all manufacturing processes are designed to change the visible properties of a material. Conditioning processes use heat, chemicals, or mechanical force to change the internal properties of materials. These processes make materials:

- Harder so they can withstand wear.
- More ductile to allow for easy forming.
- Stronger, more elastic, or stiffer to meet specific product demands.

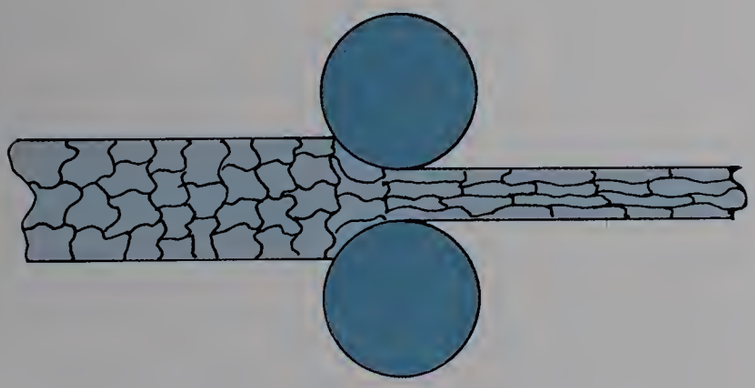


Fig. 10-12. The effects of cold rolling on grain structure are shown in this diagram.

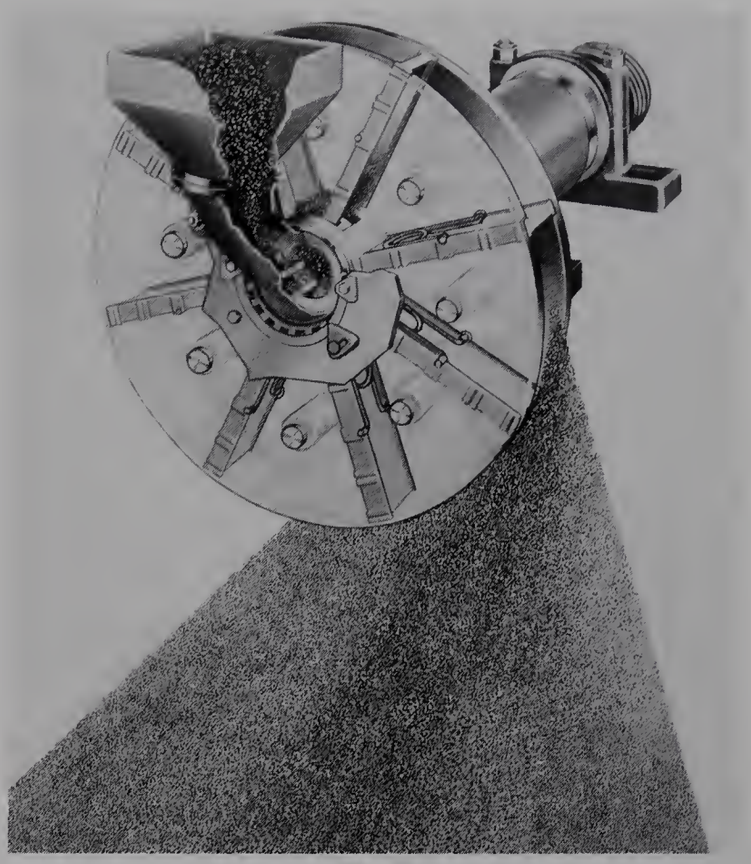


Fig. 10-13. This mechanical conditioner "throws" shot against metal to change its internal properties. (Wheelabrator-Frye Inc.)

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

annealing
chemical conditioning
drying
firing
hardening
heat-treating
mechanical conditioning
normalizing
polymerization
shot peening
tempering
thermal conditioning
work-hardening

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Processes that use heat, mechanical force, or chemical action to change the mechanical properties of a material are called _____.
2. List three factors that must be considered when selecting and using conditioning processes.

3. True or False? The specific mechanical properties a material exhibits are a direct result of its physical structure.
4. List three reasons materials are conditioned.
5. Name and describe six of the most common thermal conditioning practices.
6. True or False? Annealing and tempering increase internal stresses in materials.
7. Polymerization is an example of:
   a. Thermal conditioning.
   b. Chemical conditioning.
   c. Mechanical conditioning.
   d. None of the above.
8. Shot peening is an example of:
   a. Thermal conditioning.
   b. Chemical conditioning.
   c. Mechanical conditioning.
   d. None of the above.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Heat-treat a material. This can be a product you have cast or formed in earlier activities. For instance, you may want to heat-treat the screwdriver or tack puller blade produced in the forming activity.
   To harden a metal:
   a. Bring the heat-treating furnace up to the temperature desired. Caution: If the furnace is a gas-fired unit, follow the manufacturer's instructions in lighting it. Stand to one side and avoid looking into the fire box.
   b. Heat the metal to its critical temperature.
   c. Remove the part with preheated metal tongs. Caution: Wear protective clothing including face mask, gloves, and apron.
   d. Quench (cool) the part in the cooling solution (usually water). Twirl the part so it will cool quickly and evenly.
   e. Test the hardness with a file.

   To temper the metal:
   a. Polish about an inch of the point or edge of the part. (This will make it easier to see the change of colors as the part is heated.)
   b. Heat the metal slowly and evenly behind the polished surface as heating progresses. When the proper color appears, quench the part as in hardening. Observe the same safety safeguards as in hardening.

   There are other methods and procedures for heat-treating. Discuss the preferred method with your instructor and, if time permits, research other methods.
2. Using a common, inexpensive hacksaw blade, cut a piece of metal. Try to bend it. What happened? Anneal one piece of the metal. Using a file, cut the original piece and the annealed piece. Compare your results. Make a poster to show what you learned.

11

CHAPTER

ASSEMBLING PROCESSES

After studying this chapter, you will be able to:

- *Describe how assembly processes have evolved.*
- *Explain how bonding takes place.*
- *List five categories of bonding methods.*
- *Describe how mechanical fasteners are used in assembling processes.*
- *Give examples of permanent fasteners, semipermanent fasteners, and temporary fasteners.*
- *List five basic forms of joints.*

Think of the many products you use every day. Few are made from a single part or component. Other than nails, pins, paper clips, and buttons, few other products are made of a single part or component. Most products are composed of a series of individual parts. A common lead pencil, for instance, has at least five parts. See Fig. 11-1. The body is made up of two wood parts bonded around the graphite "lead." The eraser is held with a metal band.

Assembled products come in all sizes, as illustrated in Fig. 11-2. Some can be held in the palm of your hand, while others can carry thousands of passengers across the sea.

All multipart products are put together using assembling processes. *Assembling processes* are all practices used to temporarily or permanently attach parts to form assemblies or products.

Assembly uses two major types of processes. These, as shown in Fig. 11-3, are bonding and mechanical fastening. Bonding permanently fastens parts using heat, pressure, and/or a bonding agent. **Mechanical fastening** temporarily or permanently holds parts together using mechanical fasteners or mechanical force.

DEVELOPMENT OF ASSEMBLING

Assembling practices are about as old as civilization. Your ancestors used animal tendons to sew animal skins together to form clothing and shelters. Vines were used to lash stones onto sticks to make axes. Early assembly practices involved techniques that were like present-day sewing and lacing.

As civilization developed, humans discovered new ways to improve assembled products. By Pharaoh Tutankhamen's (King Tut's) time, wood glues were in use by Egyptians. Made from animal parts, these adhesives were used well into the 20th century. Wood products have been found in which this glue is still holding after 3300 years.

By 600 B.C., the Greeks had developed several types of metal clamps. These were used to hold building stones in place. During the European Dark Ages, cabinetmakers were using complex joints to assemble wood furniture and cabinets.

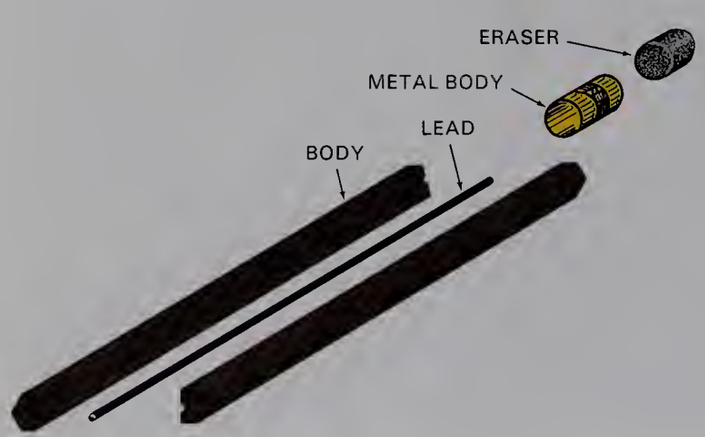


Fig. 11-1. A simple lead pencil is assembled from at least five separate parts.

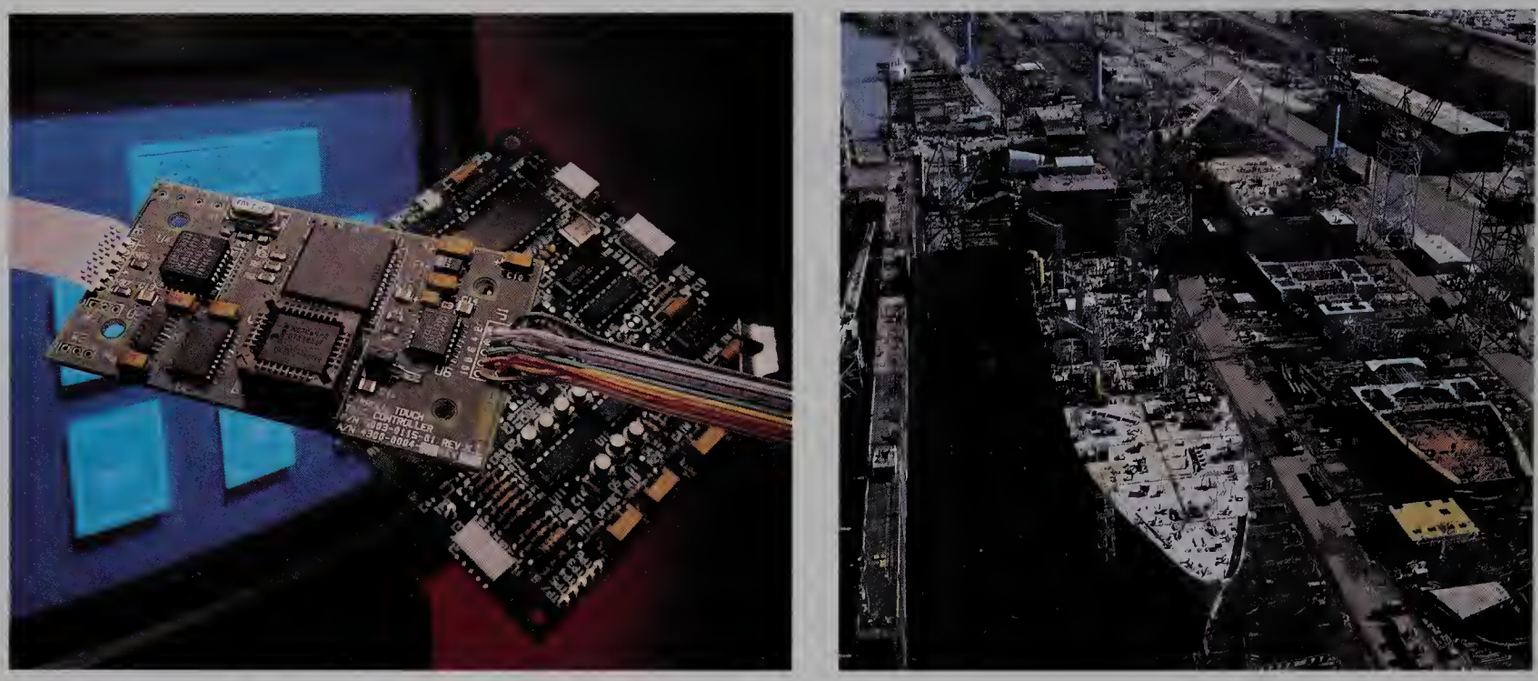


Fig. 11-2. Manufactured products may be small, complex assemblies like the computer circuits shown on the left. (AMP Inc.) They can also be huge ships, like the one shown on the right, that are made of tons of parts and subassemblies. (Colt Industries)

By 1786, a machine was developed to mass-produce nails. Before this machine was invented, blacksmiths forged the nails one at a time. Later, machines that produced bolts, screws, and other mechanical fasteners were developed.

Early artisans found that metal could be assembled without a fastener. By heating two metal parts and hammering them together, the parts could be welded into one assembly. This forge-welding practice was used by colonial blacksmiths to produce

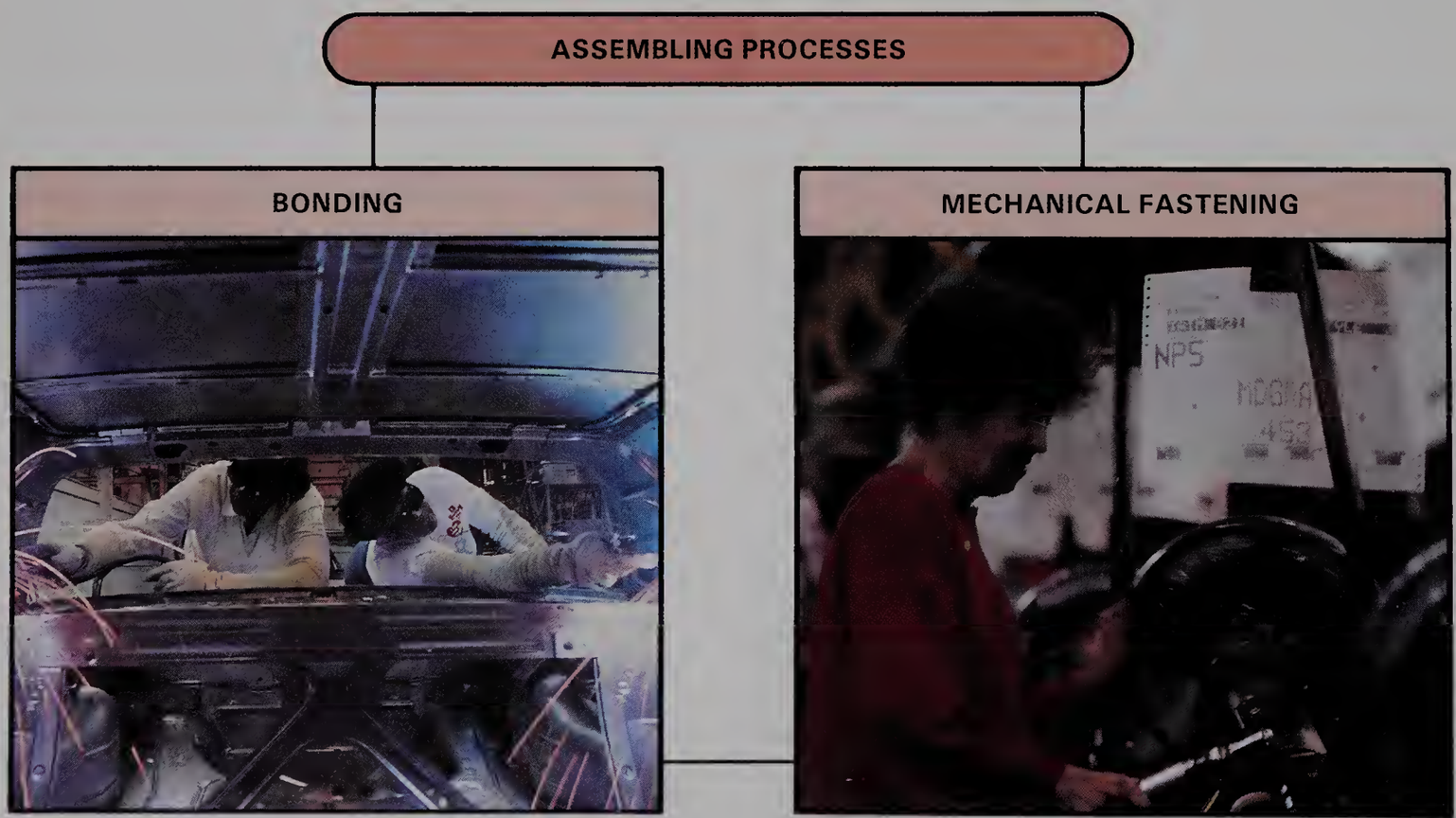


Fig. 11-3. Assembling practices can use bonding techniques such as resistance or spot welding, as shown on the left. They can also use mechanical fasteners, such as bolts and screws as shown on the right. (General Motors Corp.)



Fig. 11-4. Electric arc welding was first attempted in 1890 with a bank of lead storage batteries supplying the electrical power. (Miller Electric Mfg. Co.)

wagon tires (the steel rim that went around the wood wagon wheel). Later, heat from burning gases and electric arcs was used to weld metal parts together, Fig. 11-4. From these and other earlier discoveries, a wide array of assembling practices have developed.

ASSEMBLING BY BONDING

Bonding techniques use either cohesive or adhesive bonds to permanently hold parts together. **Cohesive bonds** are the same forces that hold the molecules of a substance together. For example, cohesive bonds hold molecules of steel in crystals, and these crystals make up the solid metal.

Adhesive bonds use the tackiness or stickiness of a substance to hold parts together. Adhesive bonds are used to glue wood parts together to form furniture.

Three essentials are considered when parts are bonded into assemblies. These are:

- The *agent* (or substance) used to bond the parts together.
- The *method* selected for creating the bond.
- The type of *joint* needed to provide a strong bond between parts.

BONDING AGENTS

Cohesive bonding requires **atomic closeness** between parts. This means that the atoms of each part must be as close to each other across the joint as they are within the parts. Under normal conditions, that closeness is not possible. Simply laying two parts together will not create a bond. Heat and/or pressure are used to produce the required atomic closeness for bonding.

Adhesive bonding requires that a film of a tacky substance be applied on the surfaces of parts that will contact one another. This material is usually an organic substance or a metal. When the parts are positioned and clamped, a bond will result. Organic adhesives form polymer chains that extend from one part to the other across the joint. The strength of the bond is related to the number and strength of these chains. Metal adhesives (solder and bronze) form a bridge between the two parts.

Most bonding processes add a bonding agent to improve the strength of the joint. These agents can be grouped under three classes:

- The *same material* as the material in the parts. For example, the parts, themselves, may be melted to produce a bond as in fusion welding.
- The *same general type of material* but different composition. For example, the agent may be a different metal as in soldering and brazing.
- A *totally different material* with special bonding properties. For example, woodworker's glue may be used to assemble a wood cabinet.

The type of bonding material (agent) and practice used will depend on the material being assembled. It will also depend on the conditions under which the assembly must function.

METHODS OF BONDING

A large number of bonding methods are used to assemble wood, plastic, ceramic, metal, and composite materials. Each technique differs in the bonding agent used and the methods used to apply the agent. See 11-5. These techniques can be grouped under five categories:

- Fusion bonding.
- Flow bonding.
- Pressure bonding.
- Cold bonding.
- Adhesive bonding.

Fusion bonding

Fusion bonding melts the edges of parts to be joined. The molten material is allowed to flow between the pieces to create a bond. The result, as shown in Fig. 11-6, is an assembly that looks and acts as a single piece of material.

Fusion bonding can be used to bond ceramics, plastic, and metal materials. This process is called *welding* when it is used on metals. However, other welding processes do not fit the fusion bonding category. Resistance welding and inertia welding are examples that fit other bonding categories.

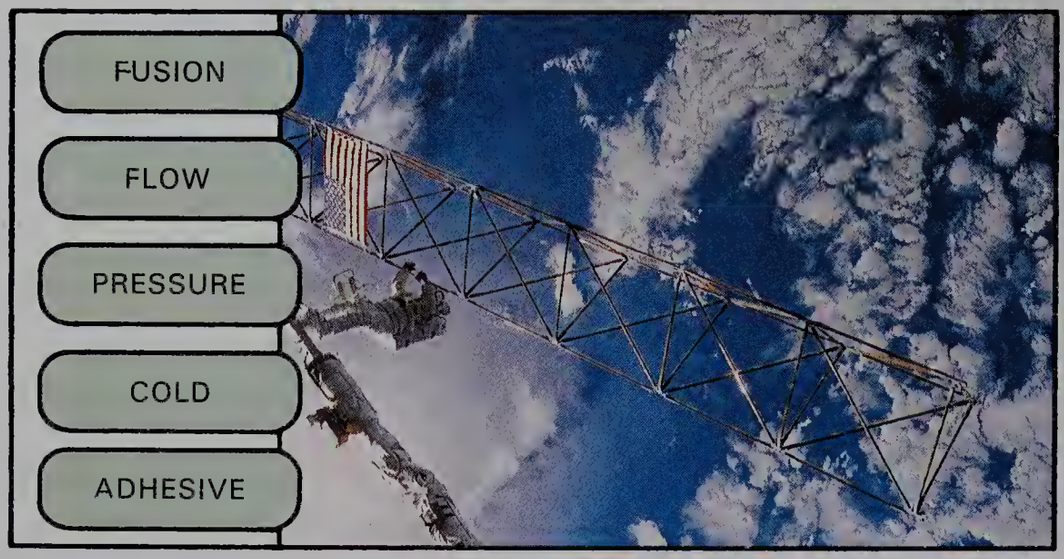


Fig. 11-5. These are the five types of bonding. How many of these do you think were used on this erectable space structure? (NASA)

The bonding agent, in metal fusion bonding (fusion welding), may be the part itself. The edges of the parts may be melted and caused to flow together. However, with materials thicker than 1/8 in., a filler material (rod) is generally used. The filler material is made up of metal that is similar to the base material.

The heat required to melt the base material and filler rods is provided by one of two basic sources, burning gases or electric arcs. The most common fusion welding techniques are named after these heat sources.

In most **gas welding,** heat is generated by burning a mixture of oxygen and acetylene. The gases, as shown in Fig. 11-7, are kept in individual pressure tanks. These gases are allowed to flow through pressure-reducing valves to a torch. Inside the torch, the gases are mixed in specific proportions. The percentage of each gas in the mixture is set by control valves on the torch. The gas mixture flows out of the torch tip where it is ignited and burns at about 6000°F (3316°C).

This temperature is sufficient to melt and fuse most common steels, aluminum, cast iron, and other metals. Most *oxyacetylene welding* is used for small quantity production, artist's work, and machine repair, Fig. 11-8. The process is slow and requires considerable operator skill.

Most production fusion welding is done with electric arc systems. The simplest is called **arc welding,** Fig. 11-9. This process uses high amperage, low voltage, alternating (AC) or direct (DC) current.

Whenever electricity jumps a gap, heat is generated. Arc welding uses this fact of physics to produce

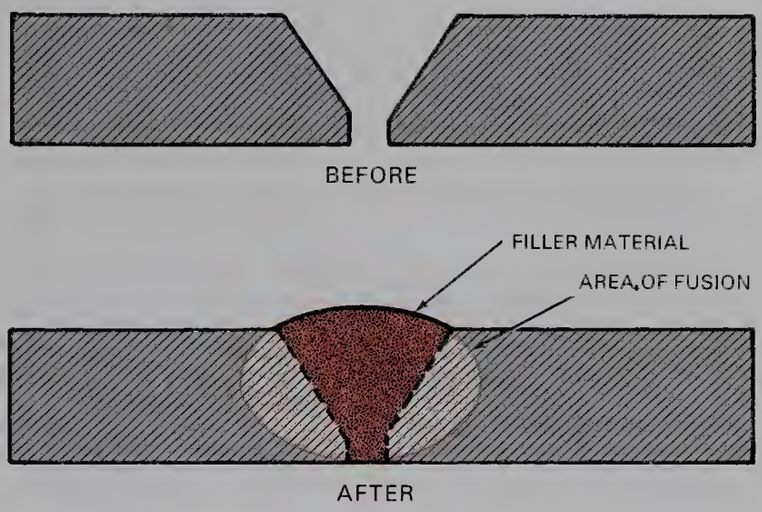


Fig. 11-6. Fusion bonded metal appears to be one piece after the bonding operation.

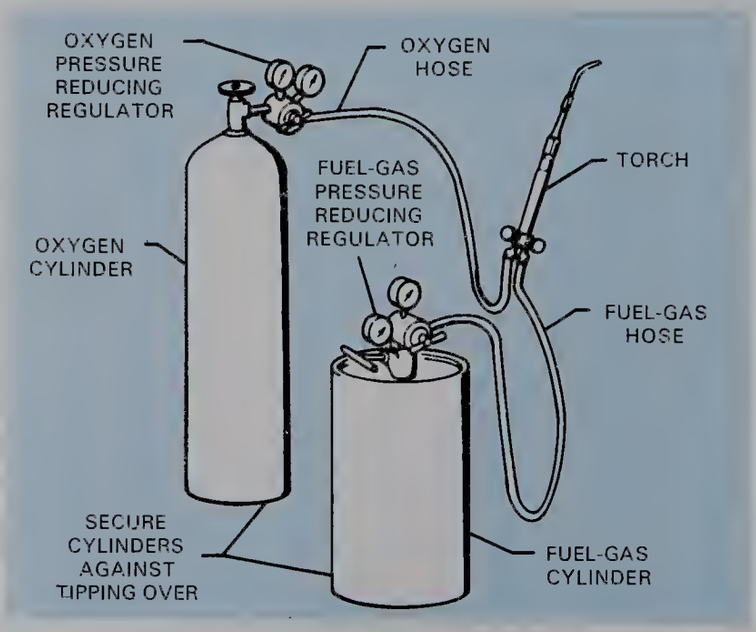


Fig. 11-7. This is a basic oxyacetylene system for gas welding. (Linde Div., Union Carbide Corp.)



Fig. 11-8. This artist is making a wire sculpture using oxyacetylene welding.

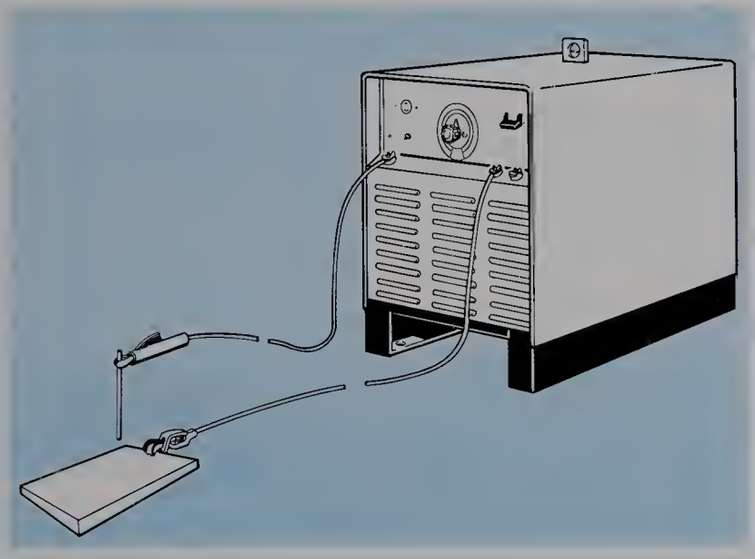


Fig. 11-9. A basic arc welding system. (Miller Electric Mfg. Co.)

welding temperatures. One side of an electrical source is attached to the work or a metal table on which the work is placed. The other lead is attached to the welding rod in a rod holder. When the rod is brought near the work, an arc is developed. This electric spark produces one of the hottest sources of energy known–about 11,000°F (6093°C). (Only nuclear reactions are hotter). This temperature can easily melt both the filler rod and the base metal. The metal from these sources flows together forming a permanent, cohesive bond between the parts.

Changes to arc welding processes have been developed. The most important of these is *shielded arc welding*, Fig. 11-10. Shielded metal arc welding uses an electrode that is a filler rod with a chemical coating. Some of the coating breaks into a cloud of protective gas when the arc is struck. This cloud provides a shield around the weld area. Other processes use a gas that is carried from a storage cylinder to the weld area. The most common of these is *gas tungsten arc welding* (GTAW). This process is also called tungsten inert gas (TIG) welding. Gas tungsten arc welding produces an arc between the work and one or more tungsten electrodes. In both of these cases, the shield protects the weld area from impurities in the air. The weld area is also protected by an inert gas.

Arc welding is used extensively for repair and maintenance work and in assembling heavy components for agricultural and construction equipment. Shielded arc welding is used in assembling nonferrous metal and speciality steel parts.

A process that is very similar to fusion bonding is **solvent bonding**. In this process, a solvent, instead of heat, is used to cause materials to flow together. Acrylic plastic parts can be bonded in this manner. The edges of parts are coated with a solvent that softens the surface. The parts are pressed together and the surfaces flow together. The solvent is allowed to evaporate resulting in a rigid assembly.

Ceramics can also be assembled by solvent processes. For example, the handles of china cups are attached to the body using this process. The ends of the handles are dipped in a slip (the same clay water mixture used to mold the handle). The liquid slip softens the handle that is pressed to the cup body. The soft clay dries, leaving the handle permanently attached to the cup body.

Flow bonding

Flow bonding heats, but does not melt the base metal, Fig. 11-11. Then a dissimilar filler metal is melted onto the hot base material. The filler metal forms a bridge between two parts with adhesive forces.

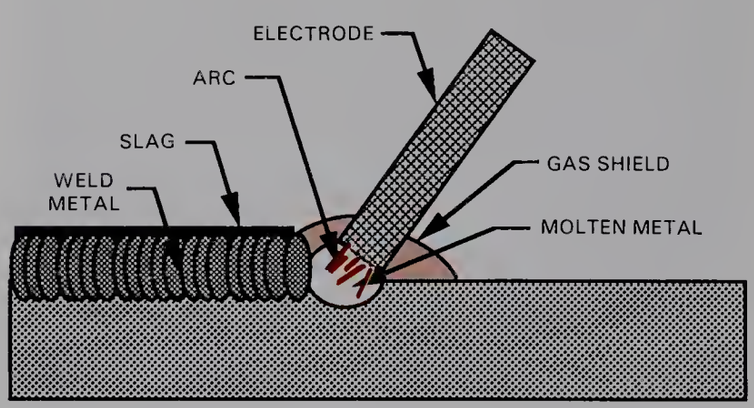


Fig. 11-10. This diagram illustrates shielded arc welding. If the gas shield were removed, it would be normal arc welding.

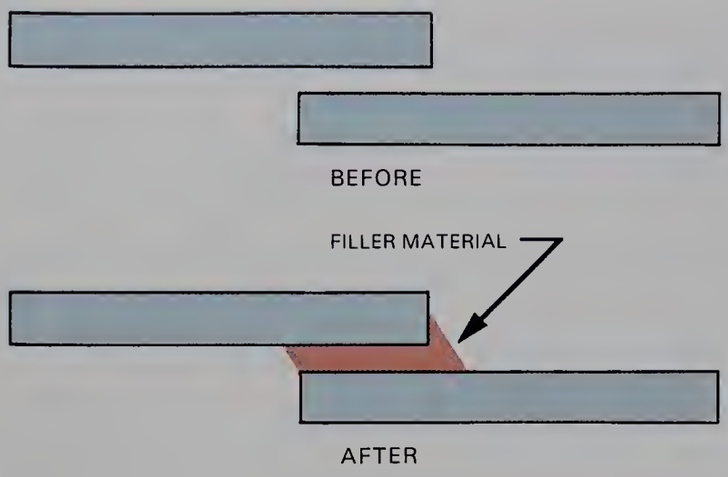


Fig. 11-11. Flow bonding does not melt the metal in the parts being joined.

In flow bonding, a clean, close-fitting joint is produced. The parts are cleaned and often coated with liquid or paste flux. This is a material that cleans the metal to improve the flow and bonding characteristics of the filler material. The parts are assembled and heated. Then one of several filler materials is melted on the joint. Capillary action (the same action that causes water to move uphill through a paper towel) causes the filler material to flow between the parts. Upon cooling, the filler material forms a strong, adhesive bond with the base material.

The two common flow bonding techniques are brazing and soldering. The difference between these processes lies in the temperatures required and in the bonding material used.

Temperatures between 1000 and 2500°F (538 and 1371°C) are used in **brazing**. This is a wide range of temperatures. The specific temperature used is determined by the base metal and the filler material being used. The most common brazing metals (filler materials) are copper, copper alloys (bronze), silver alloys, and aluminum alloys.

Heat for brazing processes is produced in three different ways:

- Placing the flame of an oxyacetylene torch on the parts.
- Placing the parts in a furnace or an oven until the filler metal melts.
- Dipping the parts into a hot bath of filler metal or flux.

The first method is similar to oxyacetylene welding. The flame heats, but does not melt, the parts. A hot filler rod is dipped in powdered flux. The rod is then heated with the flame. The flux melts and flows onto the joint. Then the rod melts and follows the flux into the joint. Upon cooling, the braze metal forms the bond between the parts.

When a furnace is used, the filler metal is preformed into discs or flat wafers. The base metal is cleaned and the filler metal is placed in the joint area. The assembly is clamped into position and put in the furnace. The heat melts the filler material that forms the bond.

The dip method is similar to the furnace method. A molten bath is used to heat the metal. In a *filler material bath*, the metal both heats the parts and forms the bond. In a *flux bath*, the parts and preformed filler are clamped together. The assembly is placed in the bath where it is heated and the bond is formed.

Brazing is used in repair and maintenance work, in fabrication of copper and brass products, and in assembling thin sheet and tubing parts. Artists also use brazing in developing metal sculptures.

Soldering is much like brazing except soldering uses an alloy of tin and lead, called *solder*, as a bonding agent. Soldering also uses a lower temperature, generally below 600°F (316°C).

The melting temperatures can be obtained with electrically heated guns and irons, Fig. 11-12, propane torches, and solder baths. The guns and torches are widely used in electrical component repair while the baths are used in the production of electronic circuit boards.

Pressure bonding

Since **pressure bonding** uses both heat and pressure to develop a bond, the term pressure bonding can be somewhat confusing. See Fig. 11-13.

Pressure alone can produce a bond. However, the great amount of force required reduces its commer-

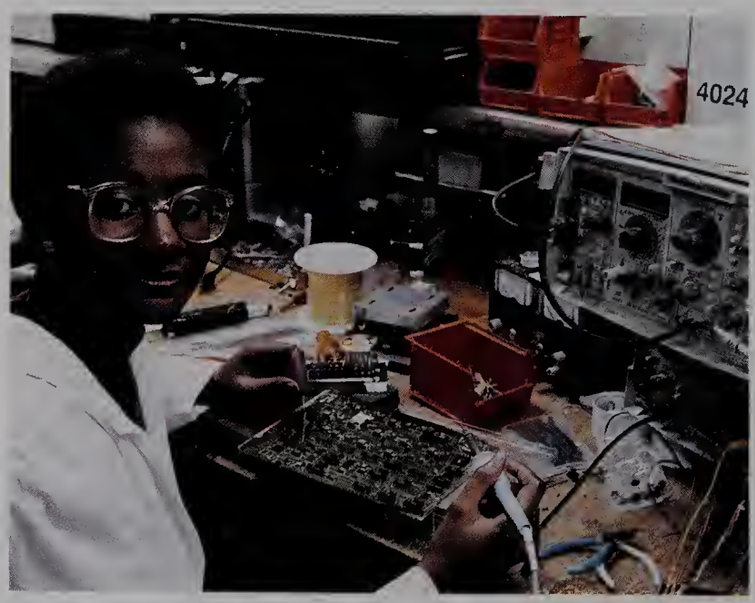


Fig. 11-12. An electronic device is being repaired with a soldering iron. (Xerox Corp.)

cial usefulness. By using heat, along with pressure, the weld can be made with less force.

In pressure bonding, the base materials (the parts) form the bonding agent. No additional filler material is added.

The most widely used pressure bonding practice is *resistance (spot) welding*, Fig. 11-14. In this practice, sheet, rod, or band steel is placed between two electrodes. Then a four-step cycle is started:

1. The electrodes are closed to apply pressure to the metal (squeeze time).
2. Electrical current is caused to flow between the electrodes and through the parts (weld time). During the weld time, a spot (kernel) of molten metal is formed between the two parts and in line with the electrodes.
3. The current is stopped and, while the pressure is maintained, the melted spot hardens (hold time).
4. The electrodes are released from the work (off time).

Resistance welding is widely used to assemble sheet metal parts. This process is common in the home appliance and automotive industries, Fig. 11-15. Probably more metal is bonded by resistance welding than in any other welding process.

Another type of pressure welding is *forge welding*. In this process, heated metal is pressed or hammered together, creating a welded joint. In forge welding, the metal is heated almost to its melting point. The surfaces are placed together. Then a hammering or pressing action creates the required atomic closeness. The force and the heat fuses the parts together. Links in common chain are assembled using this operation.

A final pressure welding technique is *inertia* or *friction welding*. In this process, one part is spun against the other part that is held stationary. See Fig. 11-16. The friction between the parts generates a great deal of heat. The heat melts the contacting surfaces of the parts. Then the rotating part is stopped

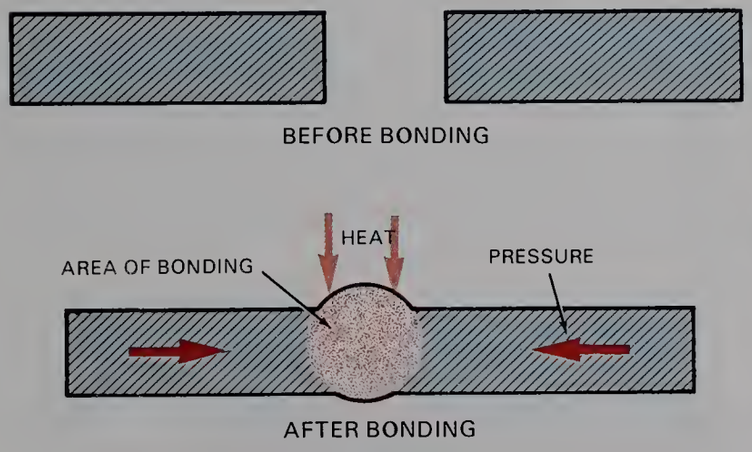


Fig. 11-13. Pressure bonding uses heat and pressure, but no filler material, to form the bond.

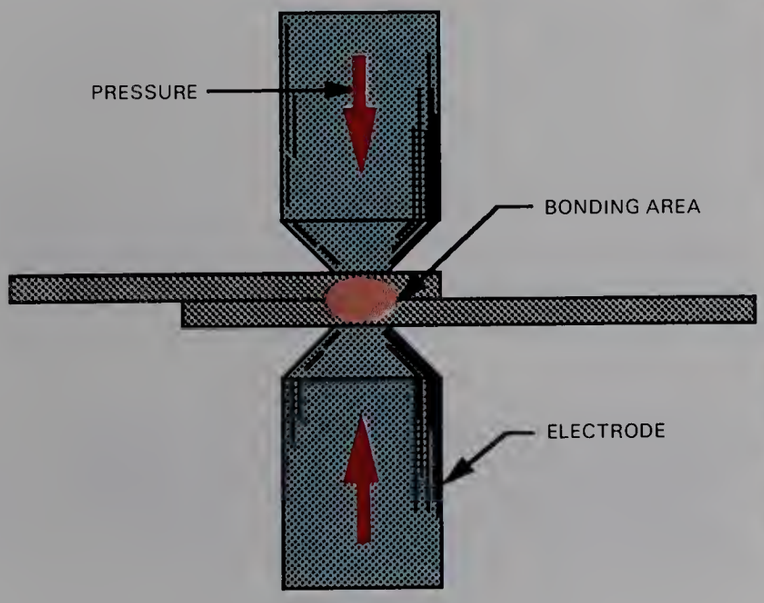


Fig. 11-14. This is the resistance (spot) welding process.



Fig. 11-15. These automobile bodies are being assembled by computer-controlled robotic resistance welders. (General Motors Corp.)

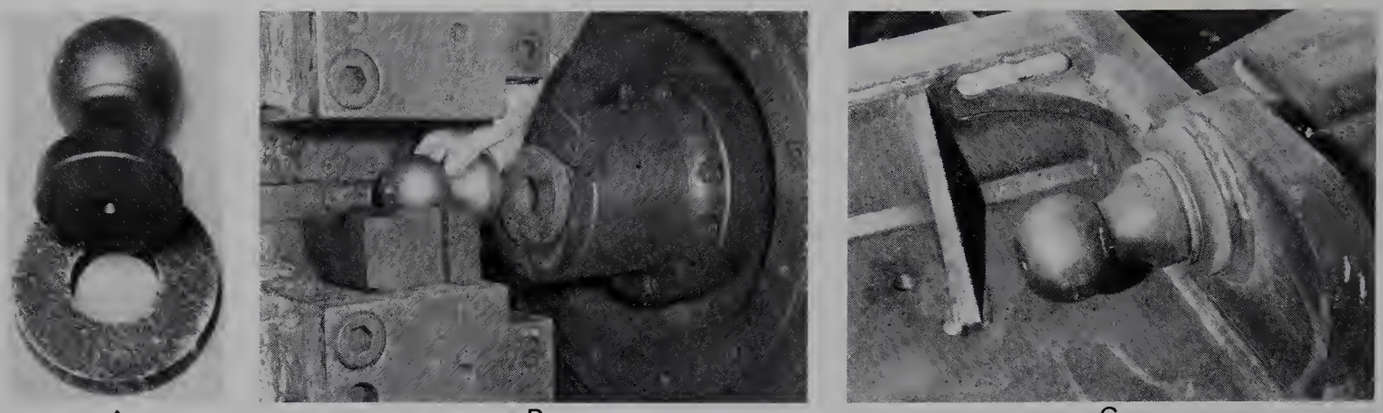


Fig. 11-16. In inertia welding, the parts (A) are mounted in a machine (B) that is like a lathe. One part is rotated against the stationary part. This causes the parts to fuse (C) into a single welded product. (Caterpillar, Inc.)

and forced into the stationary part. The result is a welded assembly.

Cold bonding

Cold bonding, involves applying great force to create the atomic closeness needed for bonding. See Fig. 11-17. This process is generally limited to very ductile metals such as copper and aluminum.

Pressures from 50,000 to 200,000 psi (pounds per square inch) are needed to create the bond. The pressure is often developed between two aligned punches.

Pressure bonding is useful in joining light-gage tubes and splicing wires. It is also used for lap joints in thin sheet metal where indentations at the weld are acceptable.

A recent development in cold bonding process is *explosive welding* or *cladding*, Fig. 11-18. In this process, two metal sheets are bonded by an explosive charge. The charge is detonated above the sheets. The shock of the explosion creates a cohesive bond between the parts. This process is used in specialized tasks such as in cladding expensive metal to inexpensive metal cores, assembling chemical process vessels, and forming tubing and channels.

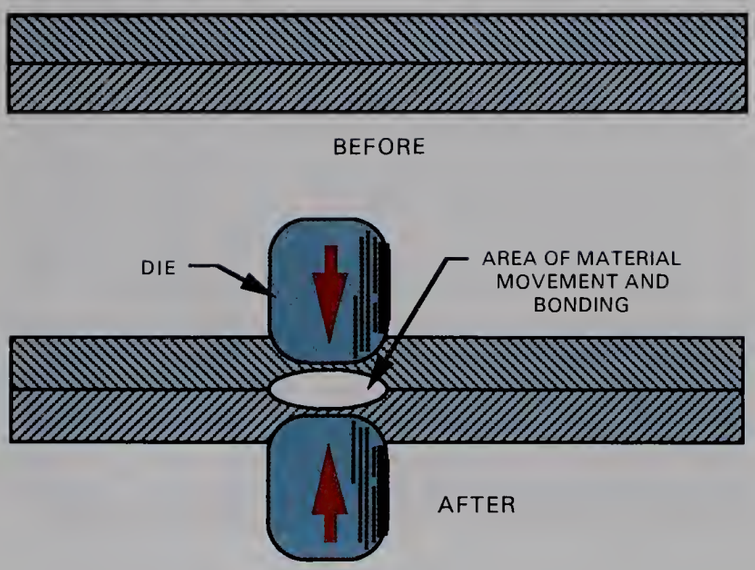


Fig. 11-17. Cold bonding uses heavy pressure to bond materials together.

Adhesive bonding

Adhesive bonding, involves permanently assembling parts using a material that has "stickiness" or "tackiness." See Fig. 11-19. In adhesive bonding, adhesive, glue, or cement is applied to the parts to be assembled. The parts are brought together where adhesive bonds form and are cured.

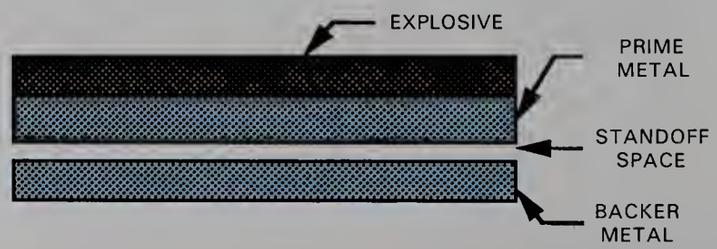


Fig. 11-18. A typical explosive forming operation is illustrated above.

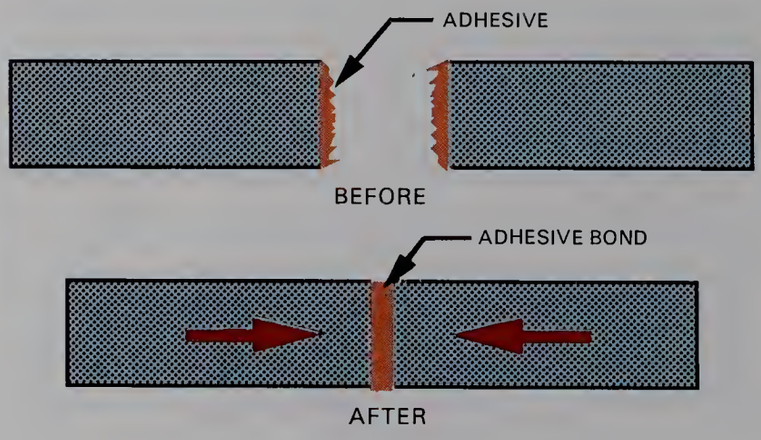


Fig. 11-19. Adhesive bonding depends on a sticky material to hold the parts in position.

The bonding agents for adhesive bonding fall into two basic classes, inorganic and organic. The typical inorganic adhesives are metal alloys used in soldering and brazing. These processes were discussed under flow bonding.

Organic adhesives can be grouped into three major types:

- Thermosetting.
- Thermoplastic.
- Elastomer.

Thermoplastic adhesives are polymers that have a basic tackiness. They are usually suspended in liquids or are produced in hot melt sticks. They achieve their adhesion when the solvent evaporates or is absorbed or when the hot melt bead cools. Thermoplastic adhesives are not waterproof or heat-resistant.

The common woodworker's white glue is an example of a thermoplastic adhesive. The hot-melt adhesives used to fabricate and close corrugated boxes also fall into this class.

Thermosetting adhesives are either powdered or liquid polymers that cure by chemical action. The curing action changes relatively simple, short polymer chains into complex, linked chains. Curing is often started by a catalyst that is added to the adhesive or is activated when water is added. Some thermoset adhesives do not cure by catalytic action, but are set with heat.

Thermosetting glue joints are strong, but brittle. They can withstand heat and varying amounts of water. Most plywood, furniture, and high-quality cabinets are assembled with this type of adhesive.

Elastomers are rubber-like adhesives. They produce a flexible bond that cannot withstand heat. Typical elastomer adhesives are rubber and contact cements. They find their widest industrial use in applying plastic laminates to cabinet faces and countertops or in pressure-sensitive labels and tapes.

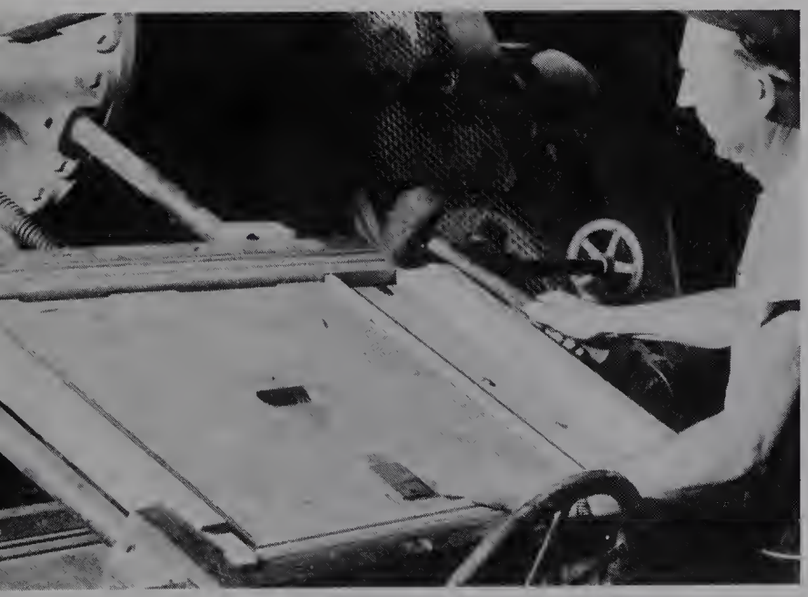


Fig. 11-20. In this process, a television cabinet section is being clamped until the adhesive sets.

Almost all adhesive assembling processes follow the same six steps. These are:

1. The adhesive material and joint are selected.
2. The material is prepared to insure a good fit, and bonding surfaces are cleaned.
3. The adhesive is applied by brushing, rolling, or spraying.
4. The product is clamped with mechanical or pneumatic (air) clamps, Fig. 11-20.
5. The adhesive is cured by drying, applying heat, or radio frequencies (RF curing).
6. The assembly is unclamped.

ASSEMBLING WITH MECHANICAL FORCES

Mechanical fastening uses either fasteners or mechanical force to hold parts together. Many of these techniques allow the parts to be assembled and disassembled easily.

FASTENING WITH MECHANICAL FASTENERS

Mechanical fasteners are devices that hold two or more parts in a specific position in respect to each other. There is almost no limit to the number or variety of fasteners available. This is because many fasteners have been developed for limited special applications.

Fasteners can be grouped in many different ways. One useful system groups them by the permanence of the assembly they produce. See Fig. 11-21.

Permanent fasteners are designed to remain in place. They can only be removed by destroying the fastener and, in many cases, damaging the assembly. The most permanent of all mechanical fasteners is the

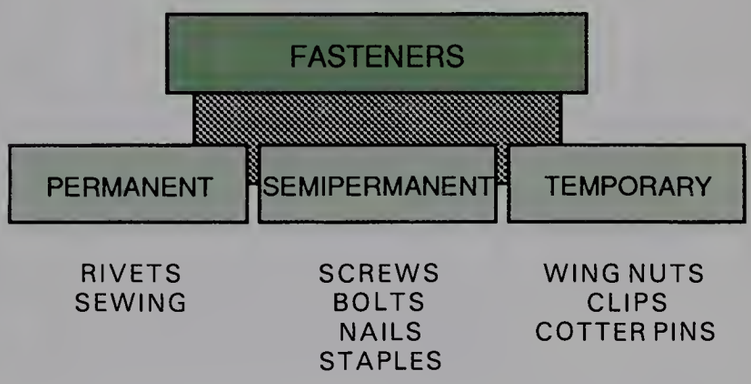


Fig. 11-21. Fasteners can be grouped into three general classes.

rivet. When installed properly, the rivet is enlarged at both ends. The assembled parts are held in position by the rivet body and the "heads" at each end. Refer to Fig. 11-22.

Rivets have been replaced by welding or adhesives in many applications. However, they are widely used in aircraft, semi and van trailers, and construction applications, Fig. 11-23.

Semipermanent fasteners are designed to remain in position. However, they can often be removed without destroying them or the materials they hold. These fasteners can be grouped into two major classes:

- Threaded fasteners: These include nuts, bolts, and screws.
- Wire fasteners: These include nails and staples.

Threaded fasteners use friction between two threaded parts to grip the assembly. For example, a bolt and nut is used to hold the seat of a bicycle in position. As you turn the head of the bolt, the nut is drawn tightly against the bicycle frame. This creates friction between the head, nut, and frame. The friction keeps the bolt in place.

In other cases, one of the parts of an assembly acts as the nut. Assume you are attaching two pieces of wood with a screw. As you turn the head of a screw, threads are cut in the bottom piece. The action draws the bottom board up against the top piece. This is the exact action that causes a nut to be draw up when the head of a bolt is turned. Again, friction keeps the screw gripping the boards, Fig. 11-24. Therefore, the more threads per inch or the larger the diameter of the fastener, the stronger the assembly will be.

Wire fasteners also use friction. When you drive a nail into a piece of wood, friction is in action. Likewise, friction keeps the nail in place and makes it hard to remove.

Some applications require easy and frequent assembly and disassembly. In these cases, **temporary fasteners** are used. Cotter pins, spring clips, paper clips, and other similar fasteners make up the temporary mechanical fastener group. These fasteners are a vital part of assembling. For example, cotter pins

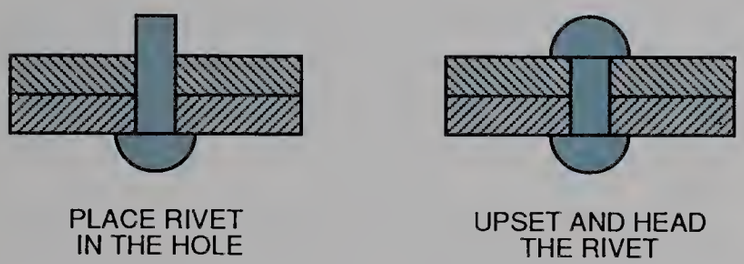


Fig. 11-22. Riveting involves two basic steps.



Fig. 11-24. Threaded fasteners are used to attach hardware to wood products. (Andersen Corp.)

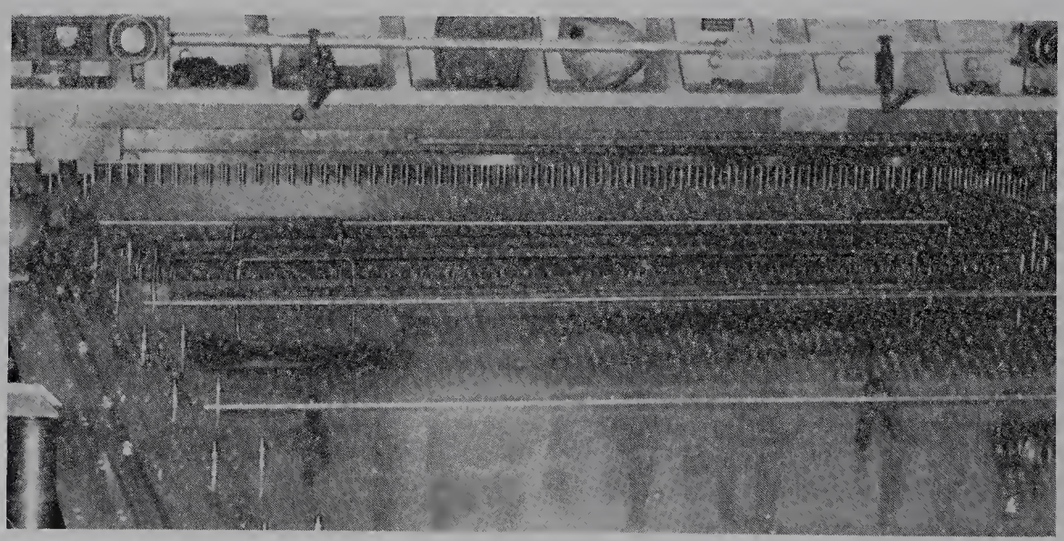


Fig. 11-23. This machine is riveting panels together for semitrailers. (Fruehauf Corp.)

keep the spindle nut on an automobile transaxle. Wing nuts are another example. They are often used to hold safety cover plates on equipment.

FASTENING BY MECHANICAL FORCE

Many parts are connected without the aid of bonding or a fastener. These techniques use mechanical force to position and hold assemblies together.

One common mechanical force assembling technique is **seaming**, Fig. 11-25. Sheet metal parts are assembled by bending and interlocking the components using various seams. The ability of the metal to retain its shape keeps the assembly together.

Another type of assembly uses **interference fits** such as press fits or shrink fits. For instance, if you watch football games, you have seen an backfield player try to gain yardage through the line. This player bumps and pushes against the line of other players. These players interfere with the progress.

Likewise, if you tried to put a round part into a hole of smaller diameter, you would encounter interference. You could put pressure (press or hammer) on the shaft to force it into the hole. This would result in a **press fit**. The friction between the larger part and the smaller hole would hold the assembly together.

In some cases, a metal part cannot be forced into a smaller opening. In a **shrink fit**, the smaller dimensioned part is heated. The expansion of the part allows easy assembly. When cooled, the part contracts (shrinks) around the other part. This creates a fit similar to a press fit.

JOINTS

In all assembling operations, there is a point where two parts come together. This point is called a **joint**. Properly designed joints increase the strength of the assembly. They also make parts alignment easier.



Fig. 11-25. This common sheet metal seam uses mechanical force to hold the parts together. The strength of the seams depends on the ability of the metal to hold its shape after it is formed.

A good joint is designed to withstand the forces that are placed on the assembly. Four basic forces must be considered, Fig. 11-26. These include:

- *Tensile stress:* These are opposite forces that try to pull the bonding agent apart.
- *Shear stress:* This is a sliding force that tries to break or fracture the bond.
- *Cleavage stress:* These are angled forces that try to rupture and tear the bond.
- *Peel stress:* This is a curving force that tries to curve one part and fracture the bond.

Most common joints are variations of five basic forms: *T-joint*, *corner joint*, *lap joint*, *butt joint*, and *scarf joint*. See Fig. 11-27. The T-joint and corner joint are used to join parts that intersect at an angle.

The lap, butt, and scarf joints are used to join parallel parts. They may be used to join the faces, edges, or ends of materials. The lap joint is strongest but does not provide a smooth joint. The butt joint forms a smooth intersection, but it is relatively weak. The scarf joint combines the advantages of both — strength and smooth intersection.

The matching of an appropriate joint with the proper bonding agent provides a serviceable assembly. Each joint is chosen to meet strength and appearance requirements.

SUMMARY

Assembling is a method of permanently, semi-permanently, or temporarily attaching parts to form

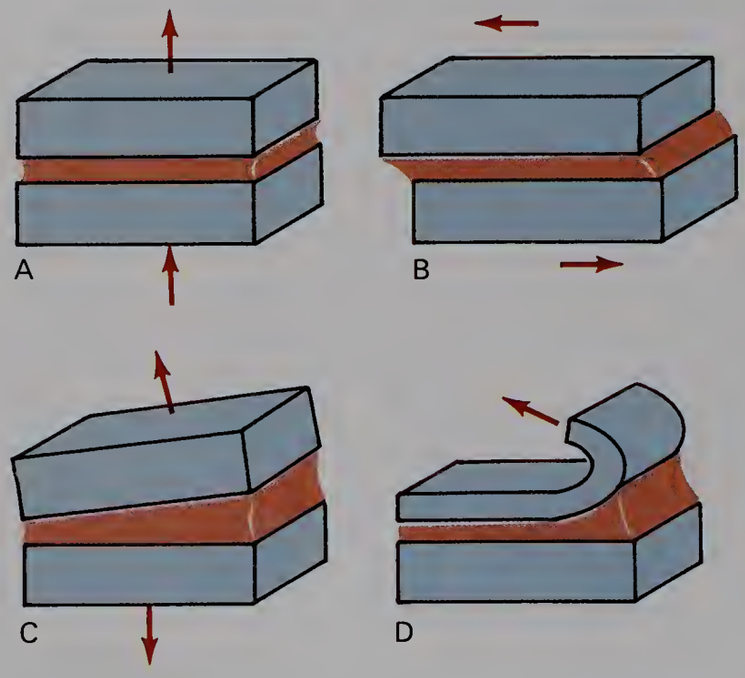


Fig. 11-26. These are four major types of stress on glue joints. A—Tensile stress. B—Sheer stress. C—Cleavage stress. D—Peel stress.

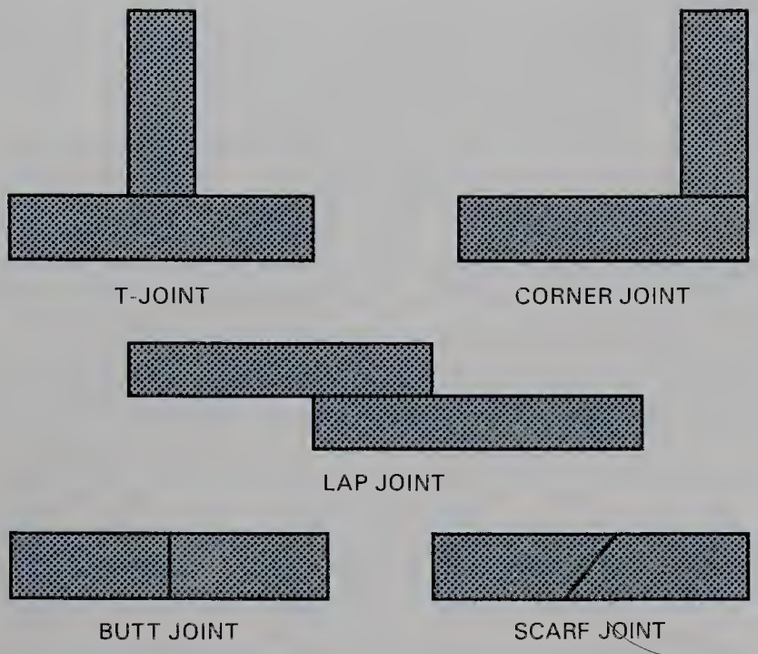


Fig. 11-27. Five basic types of joints are shown above. Joints are chosen to meet strength and appearance requirements.

products. This action may be done by bonding the parts together or by using mechanical forces.

All assembly operations must consider the agent that will be used, the method of creating the assembly, and the joint that will provide the best intersection of the parts.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

adhesive bonds
arc welding
atomic closeness
brazing
cohesive bonds
cold bonding
flow bonding
fusion bonding
gas welding
interference fits
joint
mechanical fastening
permanent fasteners
press fit
pressure bonding
seaming
semipermanent fasteners
shrink fit
soldering
solvent bonding
temporary fasteners
thermoplastic adhesives
thermosetting adhesives
threaded fasteners
wire fasteners

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. True or False? All multi-part products are put together using assembly processes.
2. Distinguish between bonding and mechanical fastening.
3. _____ bonds are the same forces that hold the molecules of a substance together, while _____ bonds use the tackiness or stickiness of a substance to hold parts together.
4. List five methods of bonding.
5. True or False? In most arc welding, heat is generated by burning a mixture of oxygen and acetylene.
6. Pressure bonding uses which of the following to develop the bond?
   a. Heat.
   b. Pressure.
   c. Both a and b.
   d. None of the above.
7. List the three major types of organic adhesives.
8. True or False? A nail is an example of a semipermanent fastener.
9. If you hammer a shaft to force it into a hole of a smaller diameter, you are creating a:
   a. Seam.
   b. Press fit.
   c. Shrink fit.
   d. None of the above.
10. Name the five basic forms of joints.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Identify products that were assembled by mechanical fastening and by bonding.
   a. Identify three products that use mechanical fastening. Identify the assembly technique used to produce each product and briefly describe the process.
   b. Identify three products that were assembled by bonding. Again, identify the assembly technique for each and briefly describe the process.

c. Organize all of your data on a chart similar to the one in Fig. 11-A.

2. Assemble parts to form. Use common assembling processes you have studied in this chapter. This could be a product of your own choice, or you could select one of the following:
   a. Make a screwdriver or tack puller from the handle produced in the casting activity (Chapter 7) and the blade produced in the forming activity (Chapter 8).
   b. Assemble the parts of the hot dish holder (trivet) produced in the separating activity (Chapter 9).

BONDING	TECHNIQUE	DESCRIPTION
Mechanical fastening 1. 2. 3. Bonding 1. 2. 3.		

Fig. 11-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.

3. Develop a transparency or chart on fusion, flow, pressure, cold, and adhesive bonding.
4. Produce several of the types of joints described in this chapter. Design a technique to test their strength. An idea for a strength test is shown in Fig. 11-B.

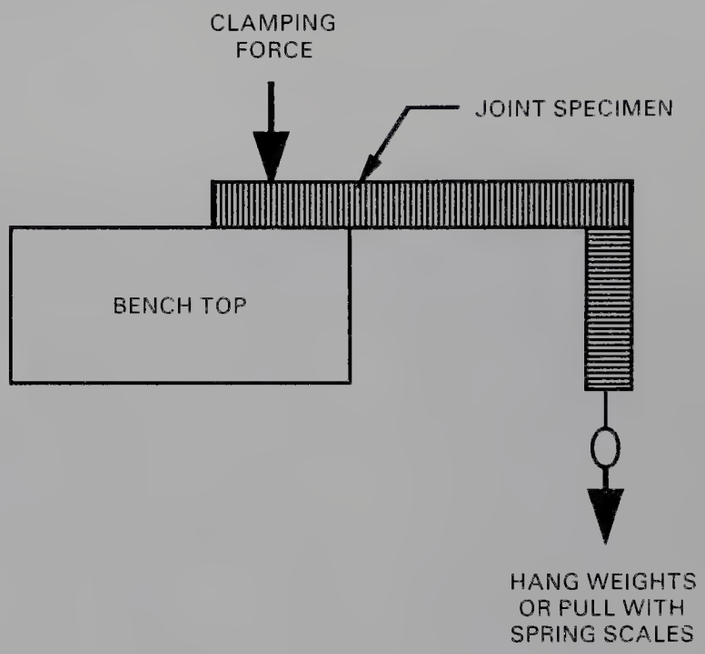


Fig. 11-B. Once you have assembled a joint, test its strength by using a test similar to this one.



These brightly finished bumpers will soon be part of a new automobile.
(Goodyear Tire and Rubber Co.)

12

CHAPTER

FINISHING PROCESSES

After studying this chapter, you will be able to:

- *Describe how finishing processes have developed.*
- *List the three basic steps involved in the application of a finish.*
- *Name and describe the two basic groups of finishing materials.*
- *Explain how materials are prepared for finishing.*
- *Describe how different finishes are applied to materials.*



Fig. 12-1. Many of the items shown in this room have had surface finishes added to them to improve their performance and appearance. (Drexel-Heritage Furnishings, Inc.)

Most consumer products–from coffee cups to wooden chairs–have a surface finish. A surface treatment applied to a material is called a finish. It includes all processes that convert or coat the surfaces of materials to beautify or protect them.

Many people are drawn to a product by its beauty. A surface finish is often applied to improve the appearance of a product. See Fig. 12-1. The result is a more attractive item that will have an increased sales appeal.

However, appearance is not the only reason surface finishes are applied to products. Surface finishes increase the durability of a product. Most industrial materials are attacked by elements in the environment. For instance, copper and aluminum can corrode. Iron and steel can rust. Wood can crack (check) and warp from absorbing and losing moisture. Water and dirt can penetrate ceramic materials. Almost all materials are subject to wear–scratching and denting. A finish is often applied to protect a material from chemicals in the air and from moisture, Fig. 12-2. The coating helps extend the life of a product.



Fig. 12-2. The yellow paint on this earthmover probably did not cause the owner to decide to buy the product. However, the paint does protect the steel parts from environmental attack that could result in rusting. (Deere and Co.)

DEVELOPMENT OF FINISHING

From earliest times, people have tried to make their surroundings more pleasant. Cave dwellers painted the walls of their caves. These paintings have been discovered in a number of locations around the world. The pictures made the walls of caves more attractive and recorded personal accomplishments. Modern finishing processes are an outgrowth of these early finishing techniques.

Nearly 10,000 years ago, the Egyptians developed painting into an art. The freshness of color and the beauty of the art found in Egyptian tomb paintings have amazed archaeologists.



Fig. 12-3. This modern Southwest Indian Pueblo pottery was hand formed and decorated.

DECORATING POTTERY

The art of making pottery (earthenware vessels) is among the oldest of all crafts. Decorating pottery began early in human history. It is believed that the first designs were used to identify the owner and the contents of the container. Later, beautification of the vessels became important.

The Greeks of 500 B.C. were noted for their black pottery decorations. Black figures on reddish clay added beauty to functional items. Similar practices were developed in civilizations throughout the world. One of these is purely American. It was developed by the natives of the Southwest (Arizona, New Mexico, and southern Colorado) long before Columbus arrived. The Pueblo Indians of that region became very sophisticated in making and decorating pottery, Fig. 12-3.

PROTECTING WOOD AND METALS

The use of wood and other fibrous materials led to the development of additional finishing materials. Early in history, wood was a primary material for all types of products. Because wood is greatly affected by changes in humidity, it can warp and check. Therefore, people devised ways to protect it from the environment. Early boat builders used reeds that grew in shallow water to make simple vessels. They found that their boats could be protected with a paste made from clay and bitumen. Later, wood boats were sealed with tar and resin collected from trees.



Fig. 12-4. Wall decoration, like this reproduction of a mural found in Awatovi, near Hopi First Mesa, Arizona, has a long history. (Maxwell Museum of Anthropology)

From these early beginnings, natural varnishes and shellac evolved. Both materials provided protection and brought out the natural beauty of wood in items such as cabinets and furniture. These materials led to the development of paint that was used to decorate household items and walls of homes, Fig. 12-4.

The protection and decoration of metals is a more recent development. As metals, such as iron and steel, became popular in everyday products, techniques were developed to prevent them from rusting and to improve their surfaces.

ESSENTIAL ELEMENTS OF FINISHING

The materials for most manufactured products are first sized and shaped using casting, forming, separating, and/or conditioning techniques. After these processes, the parts require one or more additional operations to clean, protect, and decorate the surfaces.

These finishing tasks may be completed before or after assembling. The appropriate sequence of these operations is determined by the material and processes selected.

The application of a finish requires three basic steps, as shown in Fig. 12-5. These steps are:

1. A finishing material is selected.
2. The part or base material is prepared to accept the finish.
3. The finish is applied.

FINISHING MATERIALS

Finishing materials may be divided into two basic groups. These groups consist of two types of finishes–conversion finishes and coating finishes. See Fig. 12-6.

The surface of a material may be converted into a protective layer. This action is usually carried out through a chemical process that produces a layer that is chemically different from the base material. The new layer is called a **conversion finish**. It generally has better wear properties, resistance to atmospheric chemicals, and appearance than the base material.

Conversion finishing

Colored aluminum tumblers, ash trays, and similar products have a converted surface. This finish was developed using a process called **anodizing**. This term describes an electrolytic treatment of any metal to develop a stable film or surface layer. The film is an oxide of the base metal.

All metals tend to develop an oxide coating. This coating resists further environmental attacks. Anodizing, as seen in Fig. 12-7, uses an electric current passing through an acid electrolyte (a solution that will conduct electricity). This action accelerates the natural oxidation action. The result is a uniform, hard, thicker oxide layer on the part or product. This layer accepts dye so it can also be decorative.

Other conversion finishes that are chemically developed include:

- **Phosphate conversion coating:** This is a conversion finish that is used as a prepaint coating on steel and as anti-scuff coatings on gears and engine parts.
- **Chromate conversion coating:** This is a conversion finish that can be a clear coating over cadmium and zinc-plated steel parts.
- **Oxide conversion:** This is a conversion finish that provides corrosion and abrasion resistance (blackening, nitriding).



Fig. 12-5. The three basic steps in applying finishes are outlined here. (Ransburg-Gema)

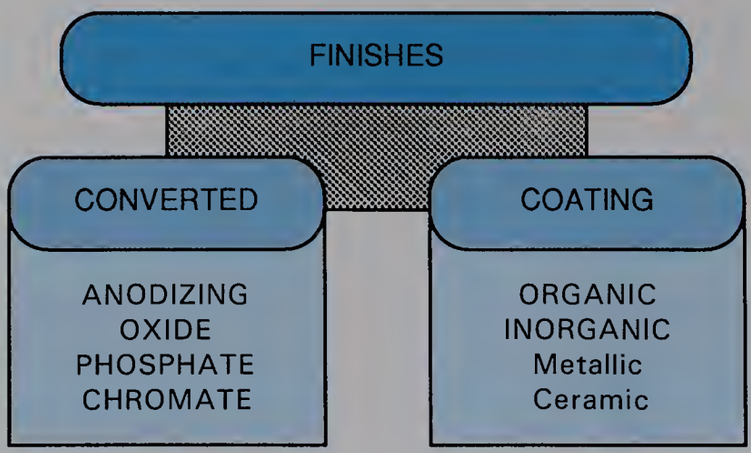


Fig. 12-6. These are the types of finishes used in manufacturing.

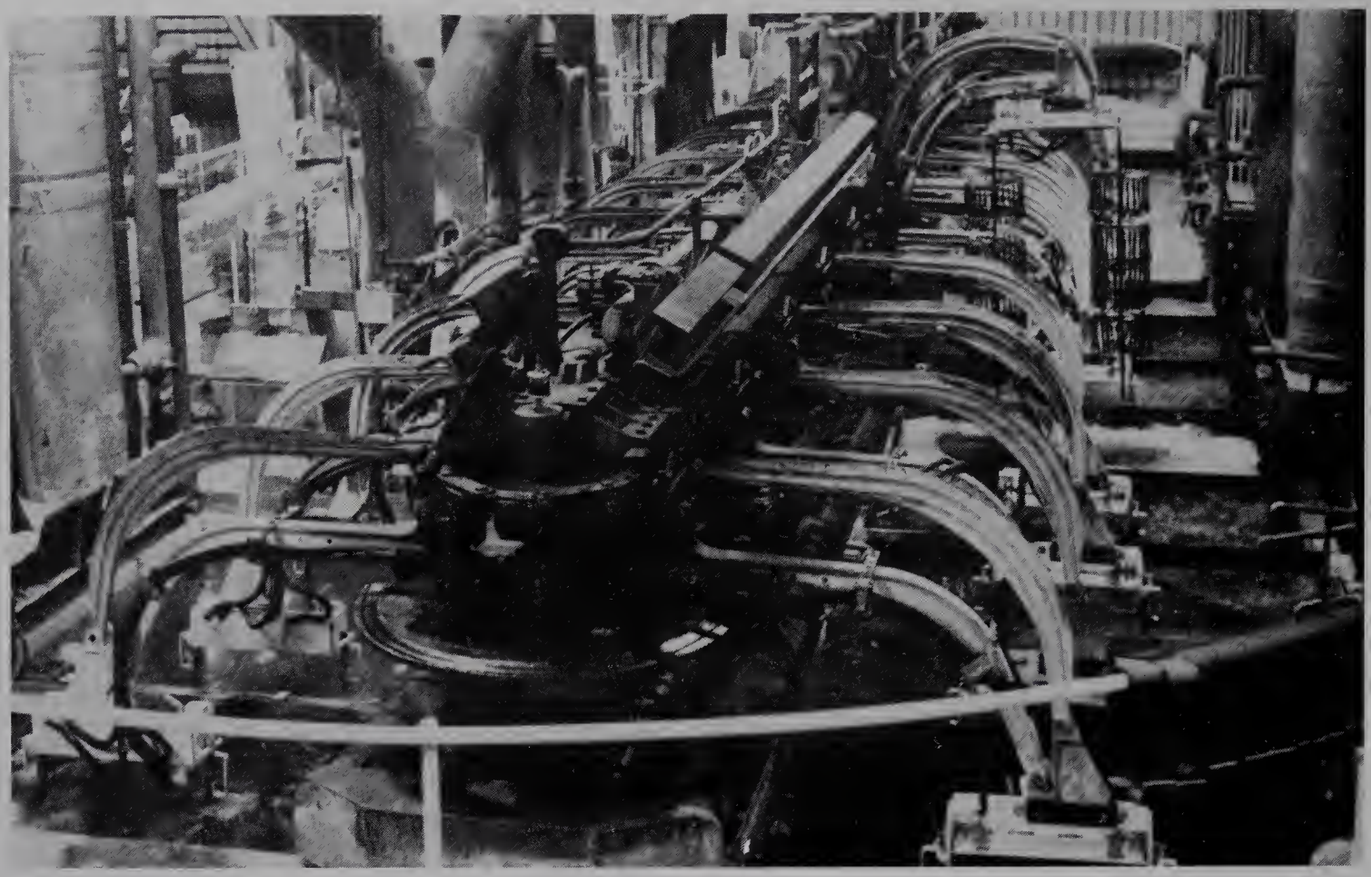


Fig. 12-7. The anodizing process includes several tanks that treat, rinse, clean, and dye the parts. The curved arms hold the parts as they are moved from tank to tank. (Mirro Aluminum Co.)

Surface coatings

Parts and products can also be coated with a layer of a second material. The result is a **surface coating**. The coating is made of one of two basic types of materials:

- **Organic coatings:** These often come from petroleum and natural gums or resins from trees.
- **Inorganic coatings:** These come from mineral-based metallic and ceramic materials.

Organic coatings are the most widely used. As with all coatings, they are designed to produce a surface layer of material that adheres to the base material. This layer seals the part or product against the outside environment, Fig. 12-8. If color is added, it can add beauty to the base material.

The term, organic coatings, covers a wide range of materials. Most of these coatings are made up of a vehicle or binder and pigments that are suspended in a solvent. The vehicle is the material that adheres to the part to provide the protection. The solvent carries the vehicle to the part. The pigment provides color to the final coating.

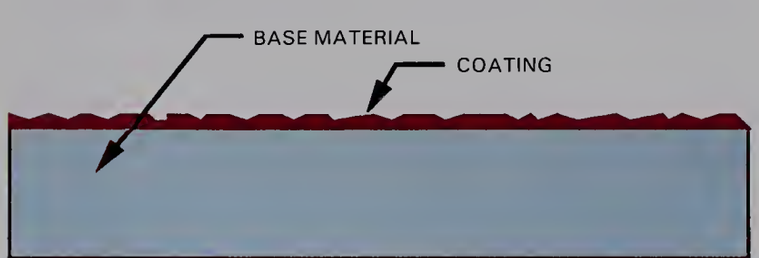


Fig. 12-8. Coating forms a protective layer of new material on top of a base material.

Organic finishes are applied as liquids. Then they must form their coating film through one of three basic actions. Some coatings are formed through polymerization. The rather simple polymer chains in the finish combine to form more rigid, complex chains. Other finishes harden through **solvent evaporation**. As the solvent evaporates, the protective coating is left behind. A few finishes are **hot melts**. They are heated and applied to the part. As they cool, a durable coating is developed.

Organic coatings include any number of specific finishes. The most common are:

- **Paint:** This is any coating that dries through polymerization. Examples include varnish and enamel.
- **Varnish:** This is a clear paint made from a mixture of oil, resin, solvent, and drier.
- **Enamel:** This is a varnish to which a pigment has been added, Fig. 12-9.
- **Lacquer:** This is a solvent-based synthetic coating that dries through solvent evaporation.

Inorganic coatings are layers of metallic or ceramic material deposited on the part. Most metallic

coatings are deposited on metal parts and products. However, coating plastics with metals is becoming more popular as plastics replace metals for automotive and appliance trim. Typical metal coatings are chromium, zinc, and tin. Decorative shapes coated with silver and gold are used to produce jewelry.

Ceramic materials make a hard, chemical-resistant finish. These coatings are all the glass and glasslike materials used on metal and ceramic items. Two common ceramic coatings include porcelain enamel and glazes. *Porcelain enamel* is used on better appliances and bathroom fixtures. *Glazes* are used to coat dinnerware, decorative objects, wall and floor tile, and other ceramic products. Both of these finishing materials consist of finely ground glass suspended in water. When heated (fired), they melt and fuse into a uniform, colorful finish, Fig. 12-10.

PREPARING MATERIALS FOR FINISHING

Most materials cannot be finished as they leave casting, forming, and separating processes. They generally require some preparation. Scratches and dents must be removed. Dirt, grease, oil, surface oxides, and other impurities must also be removed.

Material preparation activities use two basic techniques. They are mechanical preparation and chemical preparation.

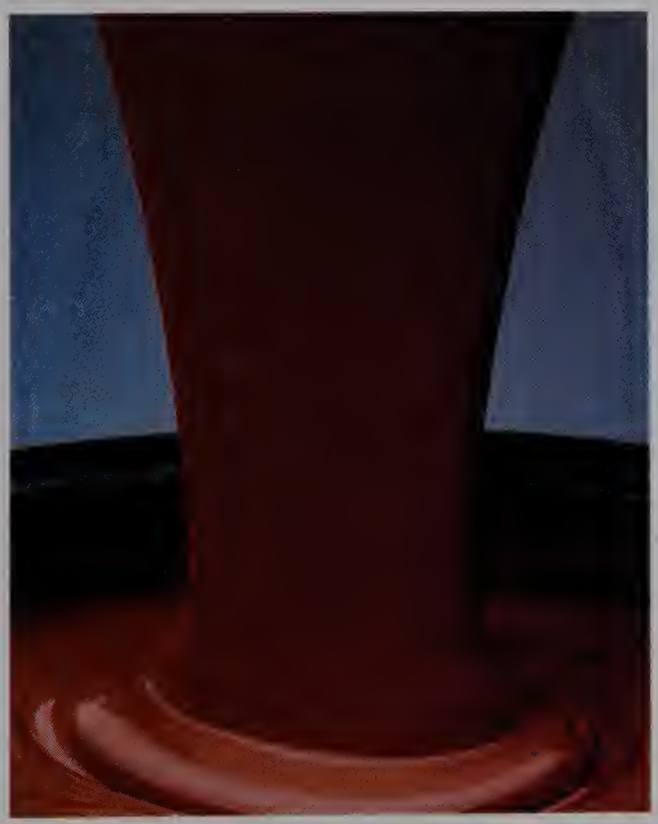


Fig. 12-9. Enamel is a colored mixture of vehicles and solvents. (PPG Industries)

Mechanical preparation

Mechanical preparation involves using a rubbing action to prepare a material for finishing. This usually means using abrasive particles, wire brushes, or metal slugs to wear off impurities and roughness, Fig. 12-11. The most common mechanical preparation processes are:

- Abrasive cleaning.
- Media cleaning.
- Brushing.

Abrasive cleaning involves using a coated abrasive paper, belt, or pad. The abrasive is used to sand, polish, or buff the material. *Sanding* is the coarsest of these operations. It uses coated abrasives to remove scratches, oils and grease, and other impurities. *Polishing* uses powdered abrasives and a pad to remove oils, greases, and minor surface defects. *Buffing* uses a pad and fine abrasives to remove the scratches produced by sanding and polishing.

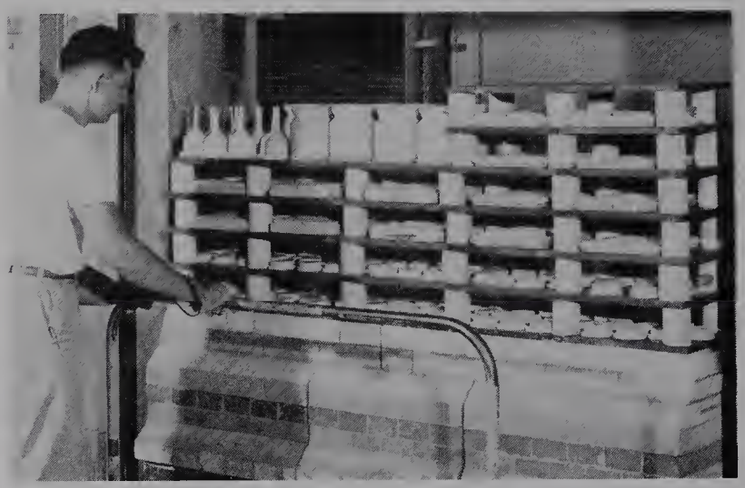


Fig. 12-10. This porcelain laboratory ware is being loaded in a kiln where it will be fired. (Coors Porcelain Co.)

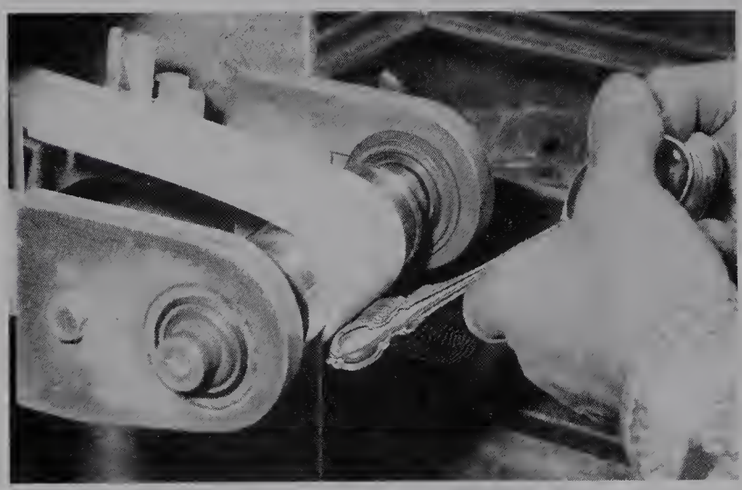


Fig. 12-11. This worker uses an abrasive belt to prepare a flatware blank for silver plating.

Media cleaning involves using fine shot or ceramic shapes to polish and remove unwanted material on the surface of the part. The media may be propelled by air against the surface (sand blasting), tumbled in a container with the parts, or vibrated against the material.

Brushing involves using a wire brush to clean the surface of a material. The rubbing action of the bristles of the brush dislodges impurities and cleans the surface.

Chemical preparation

Chemical preparation involves using chemical action to prepare a material for finishing. The material may be dipped in a chemical or may be sprayed with it. Often, the chemicals in a dip tank are agitated to increase the speed of the cleaning action. Likewise, spraying hot solvents will be faster that using cold liquids.

Chemical cleaning is often used to prepare metals to accept a metallic coating, Fig. 12-12. If the chemical is an acid, the process is called **pickling**. Alkaline solutions are used in **caustic cleaning. Steam cleaning** uses blasts of steam and detergent to remove oils and greases.

APPLYING FINISHES

Applying something often means using a process to meet a goal. You can apply a formula to a math problem to reach a solution. The problem-solving process can be applied to solve a technological or scientific problem. Likewise, you can apply a finishing process to protect or beautify a material. As you studied earlier, finishing processes can be divided into two groups in terms of the results obtained–conversion finish or a coating. Each of these results has its own technology.

Applying conversion finishes

Conversion finishes, as you learned earlier in this chapter, are developed thorough chemical means. Their goal is to change the chemical composition of the outer layer of the part or material.

One common surface conversion technique, anodizing, has already been discussed. You will recall that it is used to convert the surface of aluminum objects into aluminum oxide.

Another similar process is phosphate conversion coating. This technique involves treating the metal in a bath containing phosphoric acid and the phosphate of the base metal (iron phosphate, zinc phosphate, etc.). As shown in Fig. 12-13, the metal is dipped in a number of chemical and water baths. The process converts the surface layer of the base metal into a metallic phosphate. This layer provides an excellent base for paint, resists oxidation (rusting for iron and steel), and reduces friction.

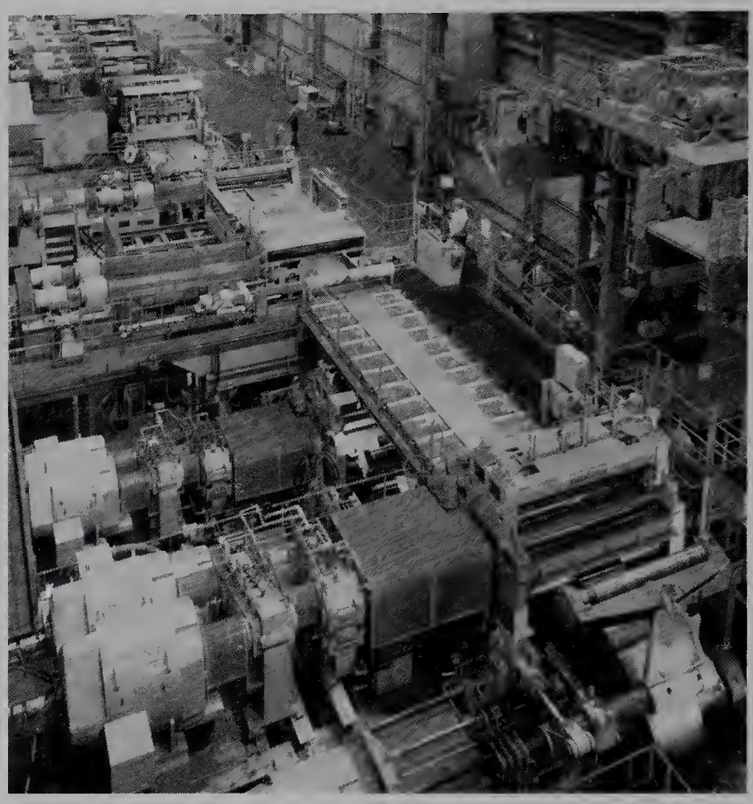


Fig. 12-12. This 84-inch-wide pickle line uses an acid bath to remove oxide coatings from sheet steel. (United States Steel)

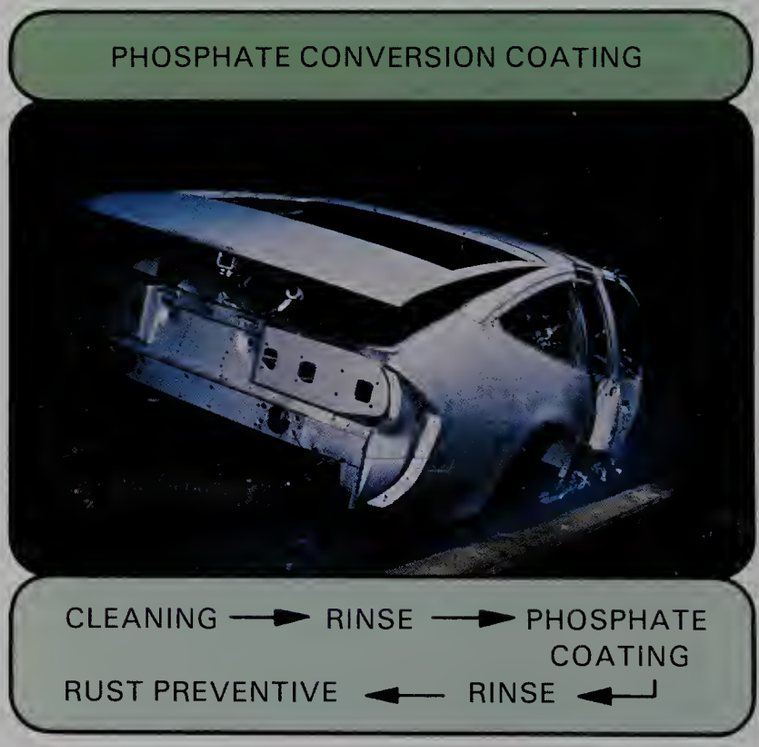


Fig. 12-13. A phosphate conversion coating is used to rustproof an automobile body. (PPG Industries)

Applying coatings

Coating finishes make up the majority of all finishes. These finishes are layers of dissimilar materials added to the surface of the base material. The coating adheres to the material to provide the desired protection and beautification. As discussed earlier, coating materials can be grouped as inorganic (metallic coatings and ceramic coatings) and as organic coatings.

Coatings can be applied using several common methods. The method selected depends on the coating material, shape of the part, and the desired appearance, Fig. 12-14.

Metallic coatings must deposit metal particles on the base material. The common processes used to accomplish this task are:

- Plating.
- Dipping.
- Metallizing.

The most common plating process is **electroplating**. This process, as shown in Fig. 12-15, involves using three components:

- A *cathode*: The part that has a negative electrical charge.
- An *anode*: A piece of plating metal that has a positive charge.
- An *electrolyte*: A liquid that conducts electricity.

In electroplating, the part (cathode) and the plating metal (anode) are placed in a vat of electrolyte, Fig. 12-16. Electrical leads are attached to the cathode and anode. The direct current is turned on causing charged atoms from the cathode to enter the electrolyte. These atoms, called ions, have a negative charge. Since opposite electrical charges attract, the ions move to the positively charged anode. There they adhere to the surface of the part. When the desired thickness is reached, the current is turned off and the part is removed. Metallic plating is widely used for jewelry, automotive trim, and hundreds of other products.

Electroplating is also used to produce coatings on industrial materials. Steel is electrocoated to produce electrogalvanized (zinc coated) and tin plated sheets, Fig. 12-17.

A second method of applying metallic finishes is **dipping**. In this process, a vat of molten metal is used. The part or material is placed in the vat. The cooler base material solidifies a thin coating of metal onto its surface.

Dipping may be used to coat individual items or batches of parts. In addition, industrial materials are

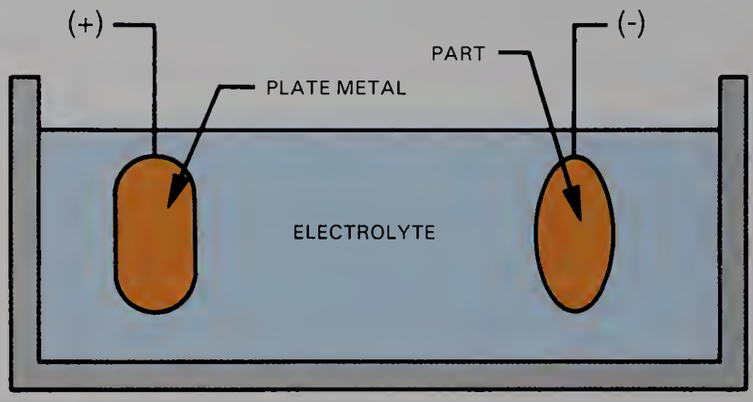


Fig. 12-15. A basic electroplating system is diagramed above.



Fig. 12-16. Electroplated parts are shown leaving a tank of an electroplating unit. (Guide Div., General Motors Corp.)

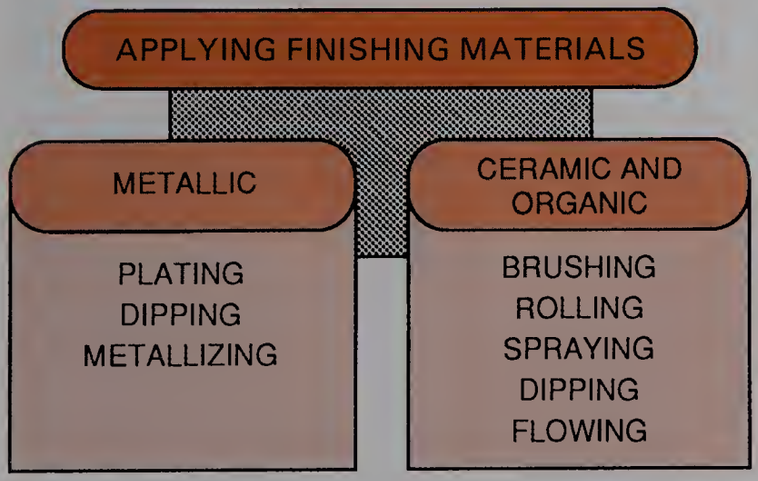


Fig. 12-14. Methods of applying finishing materials are listed above.



Fig. 12-17. Electrogalvanized sheets are shown leaving a continuous plating unit. (American Iron and Steel Institute)

often continuously fed through the vat to produce zinc (galvanized) coated sheets.

The third method of applying metallic coatings is called **metallizing**. In this process, fine, metallic particles are applied in one of three ways:

- *Wire metallizing* or *flame spraying*: The coating material is melted using a oxyacetylene flame and sprayed on the part with a blast of compressed air, Fig. 12-18.
- *Plasma arc spraying*: Powdered metal is fed into a stream of superheated gas, usually argon, that is directed onto the part.
- *Vacuum metallizing*: Metal is vaporized in a vacuum chamber where the particles float and become deposited on slowly rotating parts.

Organic and many ceramic finishes are applied using one of several techniques. These include brushing, rolling, dipping, spraying, and flow coating.

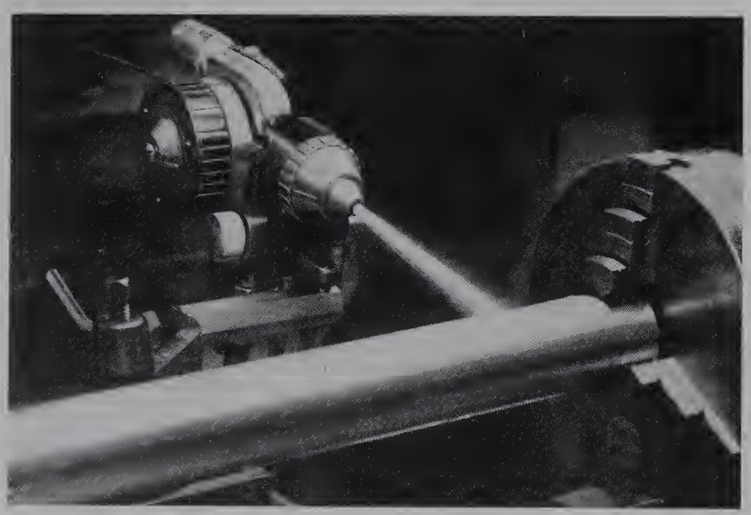


Fig. 12-18. This wire metallizing unit is applying a metallic coating to a shaft. (METCO Inc.)

Brushing is seldom used in finishing products on a commercial scale. It is the slowest finishing technique and produces the least uniform coating. Also, skill is needed to produce a high-quality brushed finish. Occasionally, brushing is used to decorate or coat unique products, Fig. 12-19.

Rolling techniques find wide use in assembly activities. Roll coating machines are often used to apply adhesives to furniture and cabinet parts and in plywood manufacturing. However, roll coating finds only limited use as a finishing technique in manufacturing. It is used in printing processes that produce the wood grain patterns of hardboard wall paneling and to coat some metal sheets.

In **dip coating**, parts or products are submerged in a vat of finishing material. The items are then removed and suspended over the container. Excess material runs to the lowest part of the product and drips off of the material. The coating is cured in the air or in an oven. Often, the finished part will have a build-up on the lowest edge or corner. This characteristic is unsuited for many applications where a very uniform surface layer is needed.

Dip coating may be used for individual parts, or it may be a continuous processes. In continuous coating, parts are suspended on a conveyor. The moving conveyor dips them into successive tanks of cleaners, rinses, and coating materials, Fig. 12-20.

Dip coating is effective when a large number of irregular parts are to be coated with the same color. Changing colors is difficult or expensive because a



Fig. 12-19. This artisan is applying 24-karat gold decoration to a piece of fine china. (Lenox China Co.)

separate tank is needed for each color. Dip coating is used to prime coat metal parts, apply glaze to ceramic ware, and surface coat small metal products, such as toys.

Many metal, ceramic, and wood products have a surface finish applied by **spraying**. The common spraying techniques, as shown in Fig. 12-21, are:

- Hand spraying.
- Automatic spraying.
- Electrostatic spraying.

Hand spraying is one of the oldest spraying techniques. The spray system is composed of a container of finish, a source of compressed air, and a gun that delivers the finish through the stream of air. Hand spraying is often used in low volume production settings, such as in many cabinet and furniture operations, and in repair and maintenance work. It finds limited use in modern high-volume manufacturing.

Automatic spraying propels a finish onto the part in the same manner as hand spraying. The difference, as shown in Fig. 12-22, lies in two factors. First, the spray head is operated by a robot or other automatic device. Secondly, parts are moved automatically past the spray heads.

Electrostatic spraying is a specialized automatic spraying operation. It uses one of the physical laws of electricity to increase the efficiency of spraying operations.

In hand spraying, a large portion of the finish material is lost to overspray. This is because the finish material misses the object at the start and end of each pass of the spray gun. Additional material bounces off the part because of the velocity it is traveling. Automatic spraying eliminates some overspray. It carefully controls the start and end of the spray pass. The introduction of airless spraying reduces the speed the finish material travels to the part. This reduces the amount of finish material that fails to stick to the surface. However, automatic spraying still presents some problems. For instance, overspray still occurs. Also, round parts have the heaviest buildup directly in front of the spray nozzle, while the top and

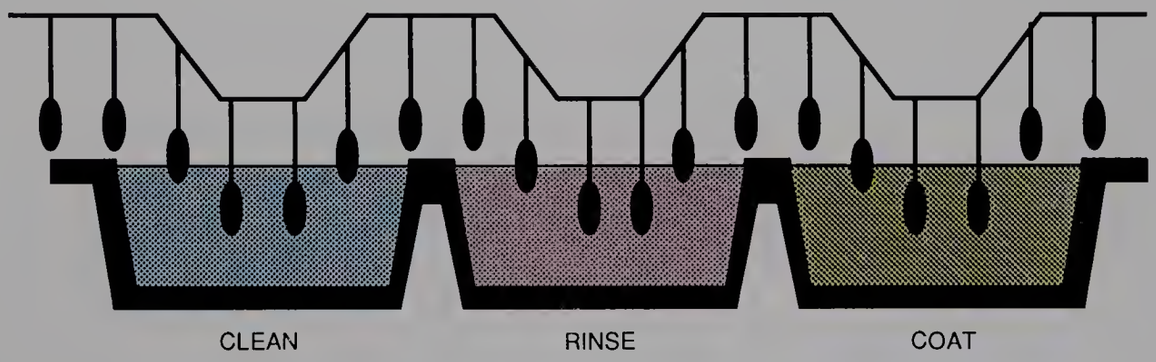


Fig. 12-20. A schematic of a continuous dip coating operation is shown here.

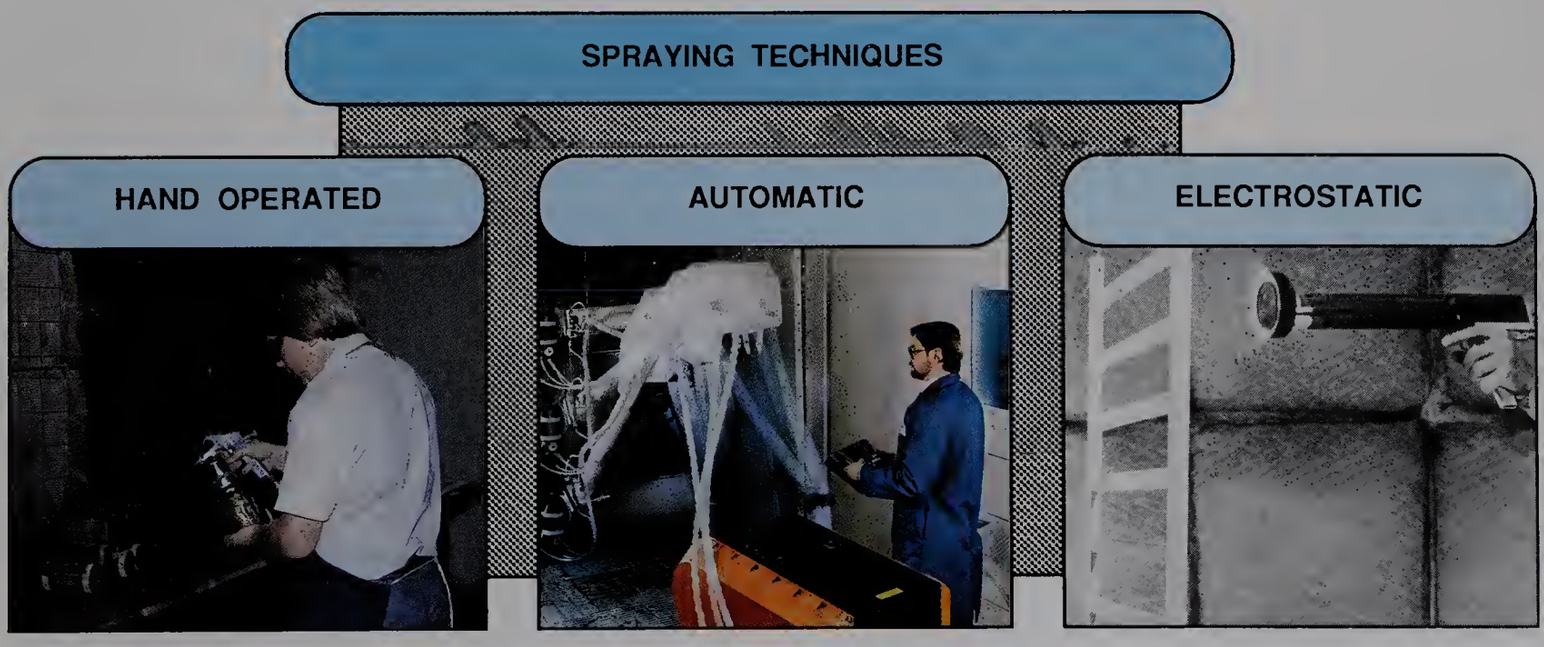


Fig. 12-21. These are types of spraying techniques used to apply finishes. (DeVilbiss Co. and Ransburg Corp.)

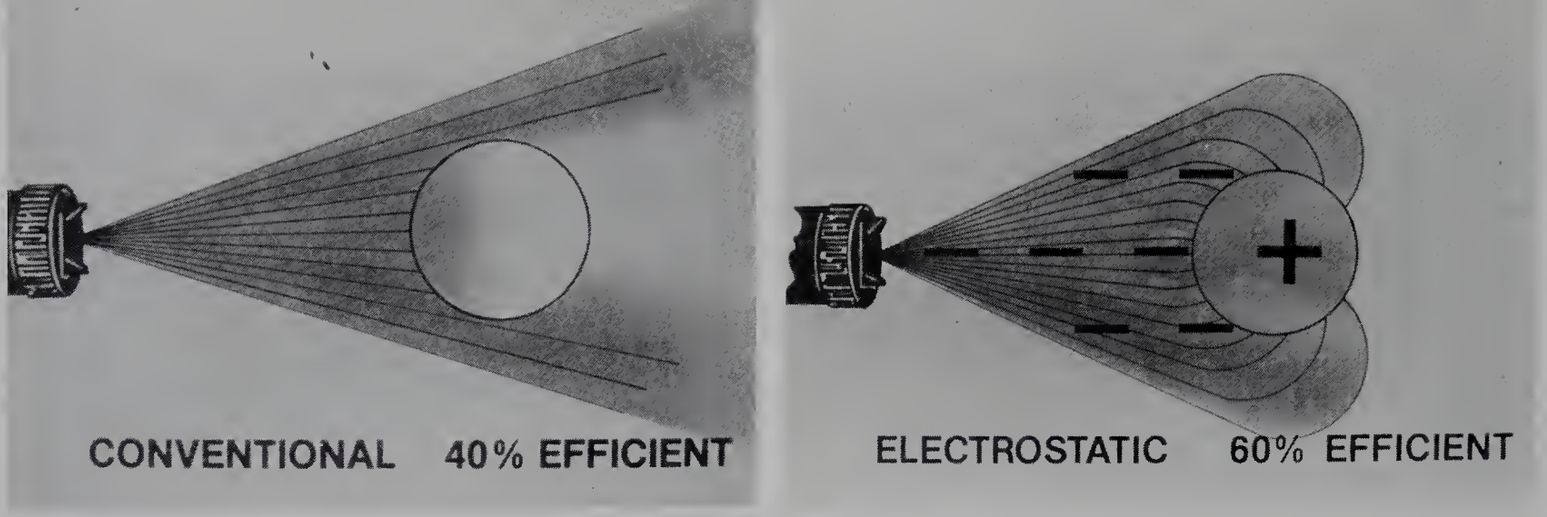


Fig. 12-22. A comparison of conventional (hand spraying or automatic spraying) and electrostatic spraying are shown above. (Ransburg Corp.)

bottom of the parts receive only a thin coat of coating material.

Electrostatic spraying solves both of these problems by giving the paint and the part opposite electrical charges. Since opposite charges attract, the paint is drawn to the part as it is sprayed. In fact, as shown in Fig. 12-23, the paint will actually wrap around the part giving a uniform coat on all surfaces.

Another coating technique is **flow coating**. This process floods the surface with finishing material. The process is very similar to dip coating, except the part is not immersed in a tank. Instead a stream of paint flows over the surface as the part moves under a nozzle. The material or product is tilted as it passes under the nozzle. The excess will flow off the part's lower edge.

Flow coating is useful in coating an exterior surface of a product or the top of sheet material. It does not work well on interior surfaces.

SUMMARY

Finishing processes are designed to protect products from environmental elements and wear. They can also be used to beautify materials by adding color and luster to surfaces.

Finishing operations must prepare the surface to accept the material. Then the appropriate finish application process must be selected and the finish applied.

A finish may be a layer of the base material that has be converted to be more attractive and corrosion resistant, or it may be a separate organic or inorganic coating material that is applied to the surface of the material or product. Coating materials are applied using plating, metallizing, brushing, rolling, dipping, spraying, and flow coating operations.

Careful attention to the selection, preparation, and application of a finish will add to the beauty and durability of products. The finish will also make the product more marketable for the company and more pleasing to the customer.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

abrasive cleaning
anodizing
caustic cleaning
chemical preparation
chromate conversion coating
conversion finish
dip coating
dipping
electroplating
enamel
flow coating
hot melts
inorganic coatings
lacquer
mechanical preparation
media cleaning
metallic coatings
metallizing
organic coatings
oxide conversion
paint
phosphate conversion coating
pickling
rolling
solvent evaporation
spraying
steam cleaning
surface coating
varnish

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. True or False? Surface finishes are applied only to improve the appearance of products.
2. List the three basic steps involved in the application of a finish.
3. Name the two basic groups of finishing materials.
4. True or False? Organic coatings come from mineral-based metallic and ceramic materials.
5. Which of the following finishes is a solvent-based synthetic coating that dries through solvent evaporation?
   a. Paint.
   b. Lacquer.
   c. Varnish.
   d. Enamel.
6. List three types of mechanical preparation processes for finishing.
7. List three types of chemical preparation processes for finishing.
8. Anodizing is an example of a _____ finish.
9. _____ finishes are layers of dissimilar materials added to the surface of the base material.
10. Which of the following is used in applying metallic finishes?
    a. Dipping.
    b. Metallizing.
    c. Electroplating.
    d. All of the above.
11. True or False? Brushing is often used in finishing products on a commercial scale.
12. In which of the following coating techniques is a part or product submerged in a vat of finishing material?
    a. Rolling.
    b. Dip coating.
    c. Spraying.
    d. Flow coating.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with finishes. Your instructor will provide safety instructions.

1. Apply a common finish to a product.
   a. Select a product and a finish. Suggestion: dip finish the trivet produced during the separating activity in Chapter 9.
   b. Examine the surface of the product. Is it ready for finishing? It may require cleaning, smoothing, or some other preparation.
   c. Prepare surface as may be required.
   d. Procure finishing materials.
   e. Select tools and equipment needed.
   f. Apply the finish. (Note: if you use volatile materials or spraying on finishing material, be sure to use proper ventilation and wear a mask or respirator. Check safety equipment with your instructor.)
2. Apply three different wood finishes to sample wood blocks. Wrap a piece of 120 grit abrasive paper to a brick or other weight. Attach a string to the weight and drag it across the wood samples 1, 5, 10, and 20 times. Observe and record your results for each test on a chart similar to the one in Fig. 12-A.
3. Collect five samples of materials that have a finish applied to them. Prepare a label for each, similar to the one in Fig. 12-B.

TIMES	SAMPLE	RESULTS	CONCLUSIONS
1	1		
5	1		
10	1		
20	1		
1	2		
5	2		
10	2		
20	2		
1	3		
5	3		
10	3		
20	3		

Fig. 12-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.

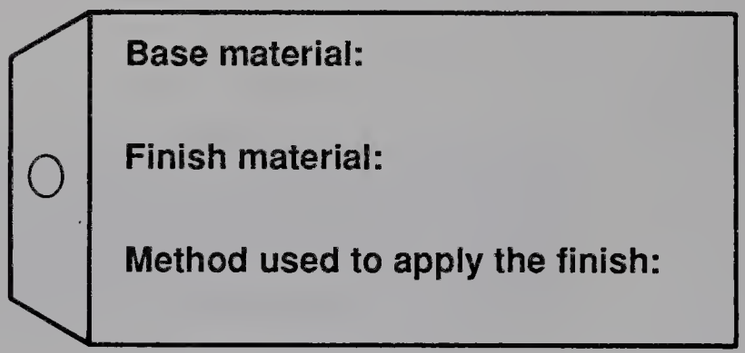


Fig. 12-B. Prepare labels similar to this one. Analyze each sample and fill in the labels.

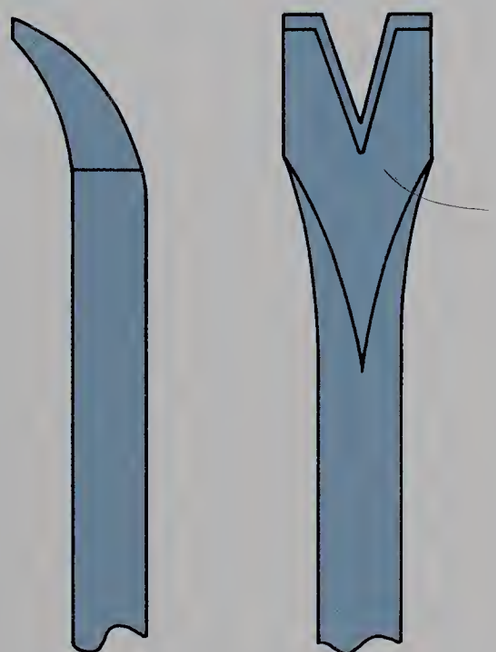
TACK PULLER OR SCREWDRIVER

BLADE

MODULES COVERED

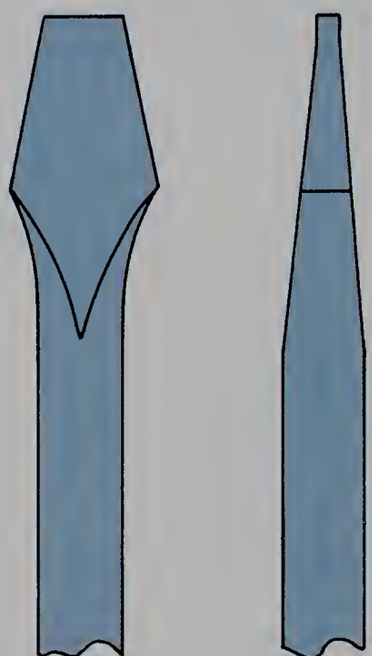
SEPARATING	→	FORMING	→	CONDITIONING
Cutting Filing		Forging		Hardening Tempering

TACK PULLER



MATERIAL–DRILL ROD

SCREWDRIVER

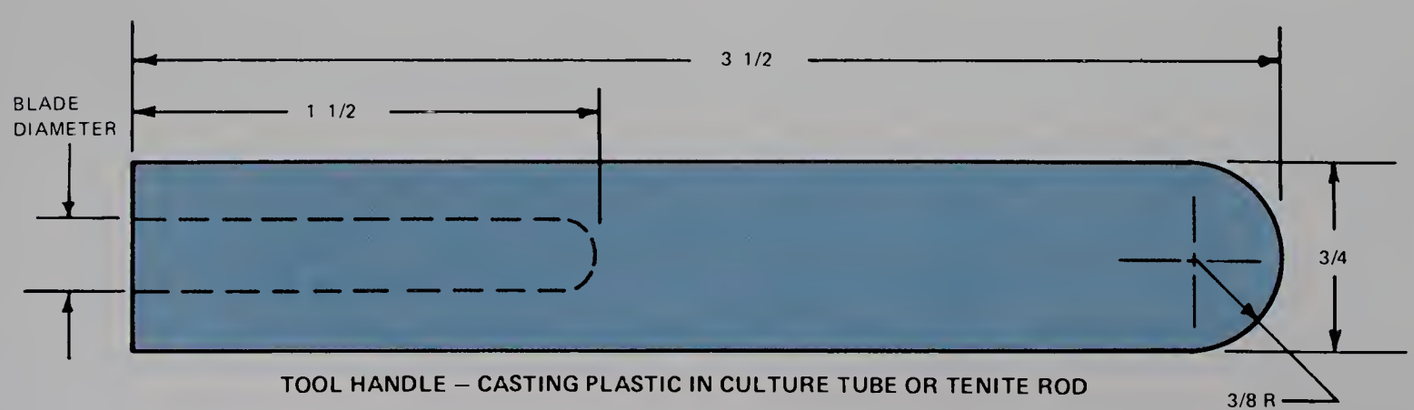


MATERIAL–DRILL ROD

HANDLE

MODULES COVERED

CASTING	→	SEPARATING	→	ASSEMBLING
Permanent Mold (cast handle option)		Cutting Drilling Sanding Polishing		Adhesive



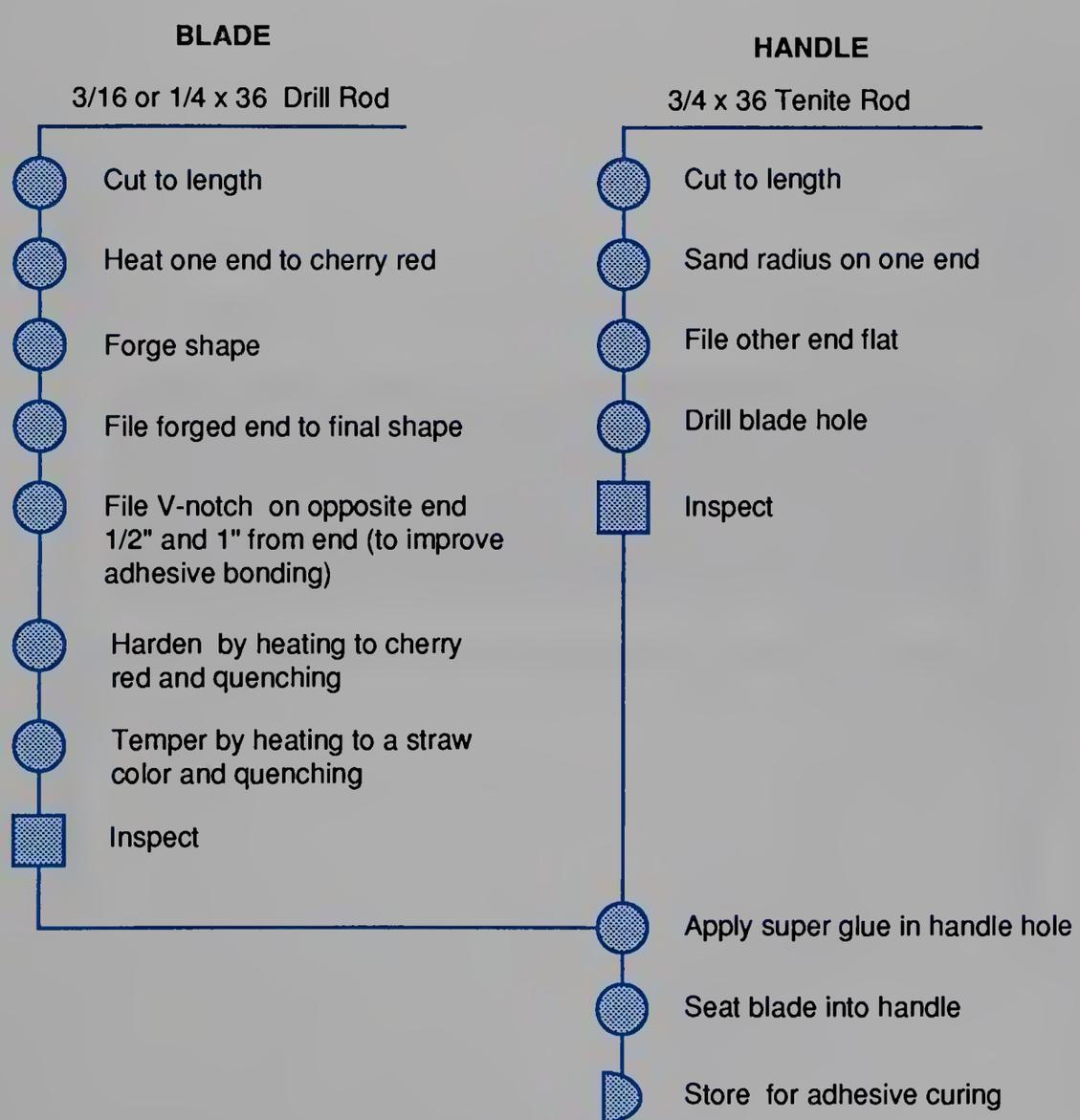
TOOL HANDLE – CASTING PLASTIC IN CULTURE TUBE OR TENITE ROD

TACK PULLER OR SCREWDRIVER

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L	Material
1	Blade	3/16 dia or 1/4 dia	Drill rod
1	Handle	3/4 dia	3 1/2 Tenite rod

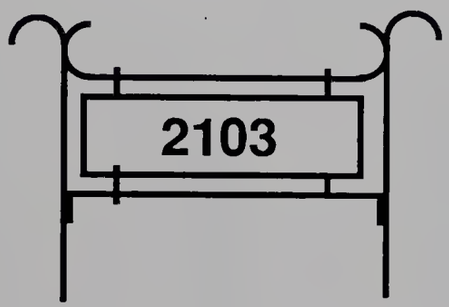
OPERATION PROCESS CHART



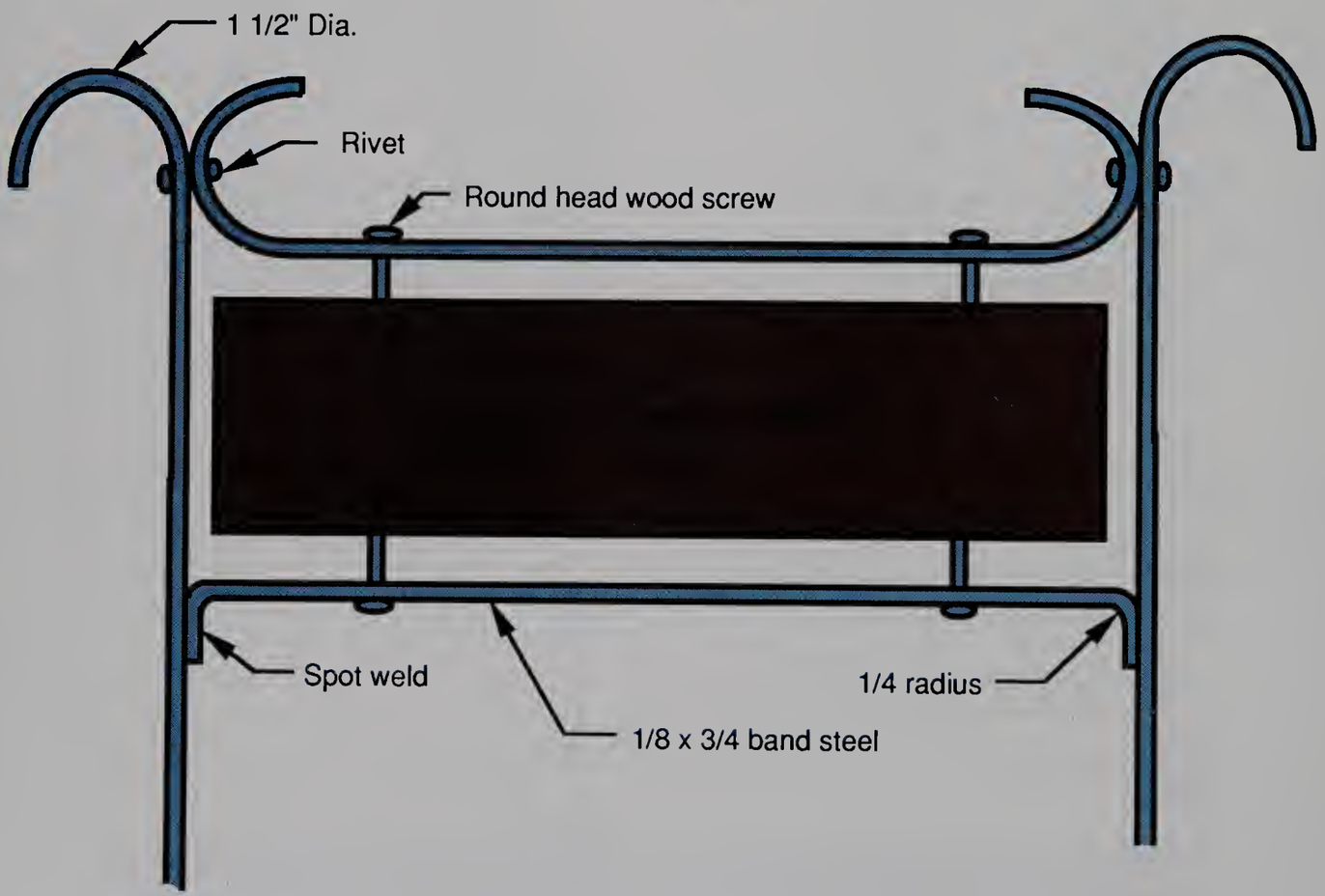
ADDRESS MARKER

MODULES COVERED

FORMING	SEPARATING	ASSEMBLING	FINISHING
Bending Roll forming	Cutting Filing Sanding Drilling	Mechanical fastening Fusion bonding	Brushing or Spraying



Note: The length and width of the address board may be adjusted to fit needs. As the size of the address board is changed, so must the length of the metal parts. Also, the leg length should be varied to match the type of soil in the yard. Sandy soil will require longer legs than clay soil.

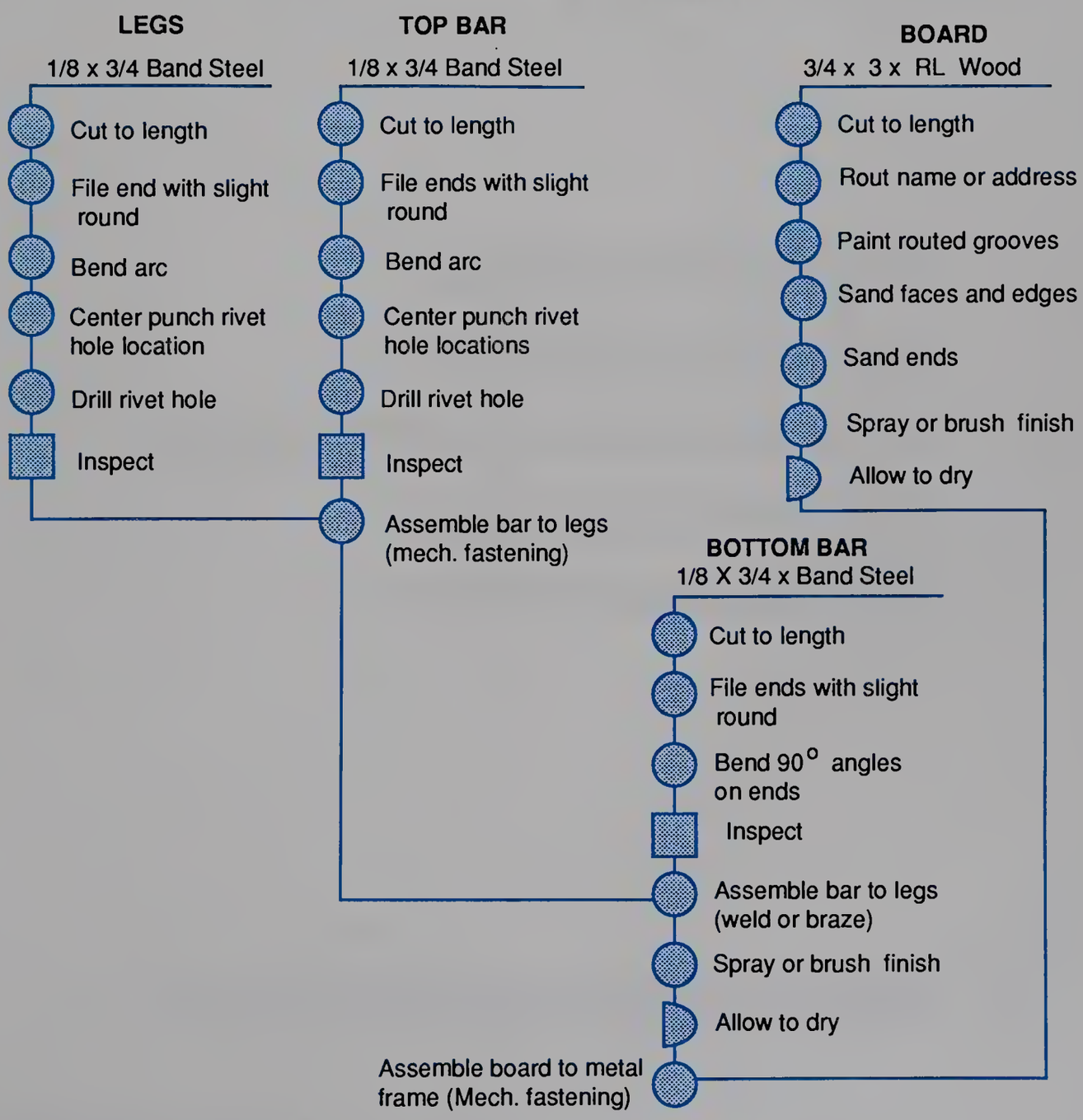


ADDRESS MARKER

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
1	Board	3/4	3	9	Redwood or pine
2	Legs	1/8	3/4	18	Steel
1	Top bar	1/8	3/4	13	Steel
1	Bottom bar	1/8	3/4	11	Steel

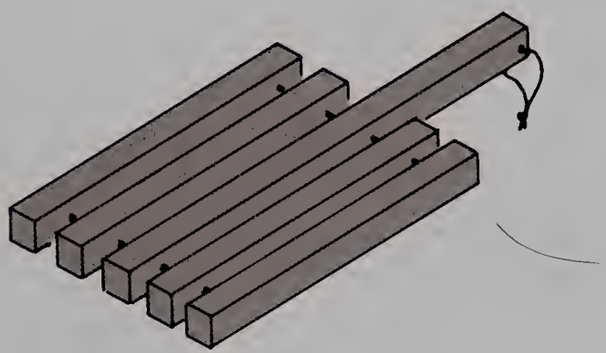
OPERATION PROCESS CHART

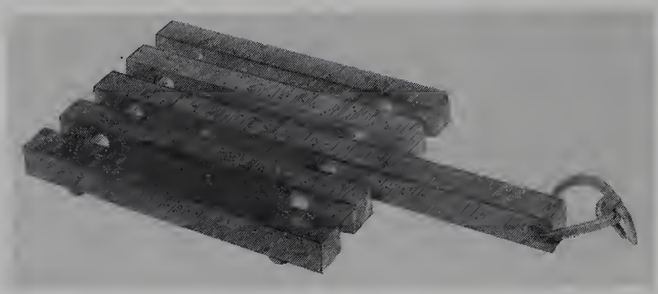


TRIVET – HOT DISH HOLDER

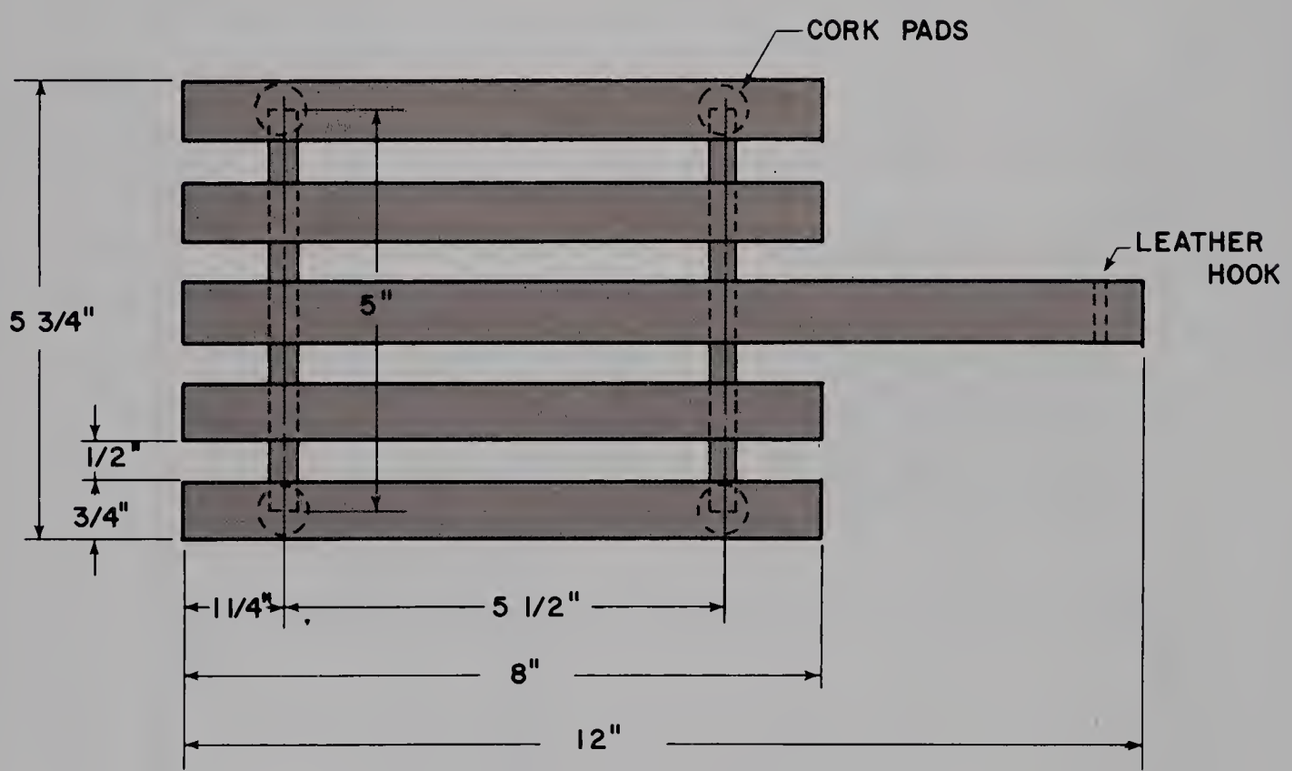
MODULES COVERED

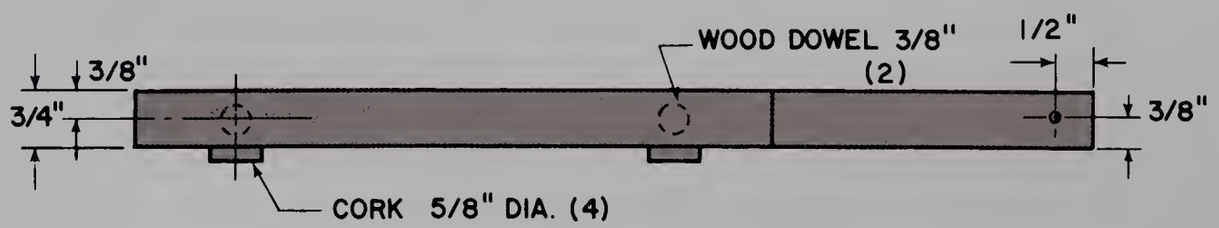
SEPARATING	ASSEMBLING	FINISHING
Cutting Drilling Sanding	Adhesive Mechanical Fastening	Dipping or Brushing





HOT DISH HOLDER – TRIVET



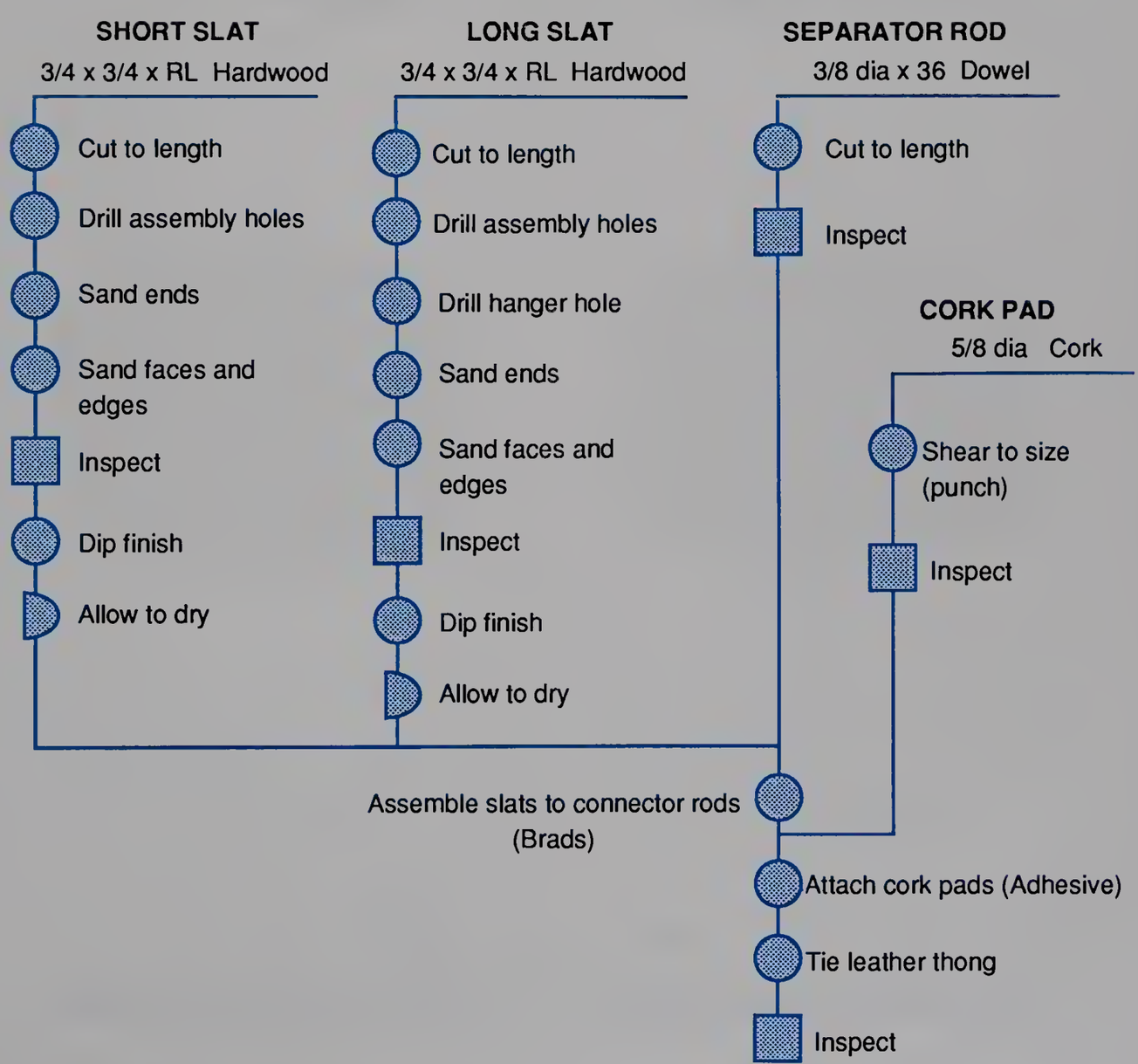


TRIVET – HOT DISH HOLDER

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
4	Short slats	3/4	3/4	8	Maple, walnut, or poplar
1	Long slat	3/4	3/4	12	Maple, walnut, or poplar
2	Separator rods	3/8		5	Birch dowel
4	Cork feet	5/8 dia			Sheet cork
1	Leather hook			6	Boot lace

OPERATION PROCESS CHART

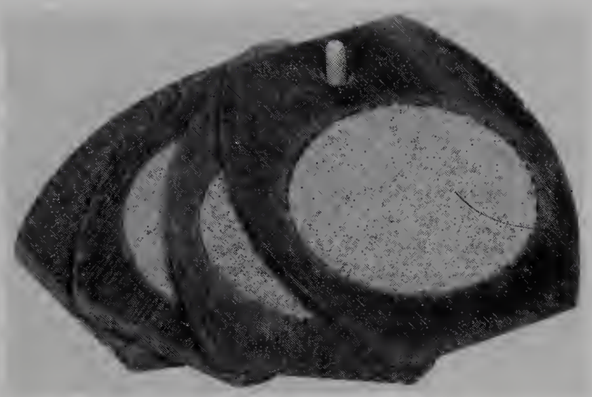


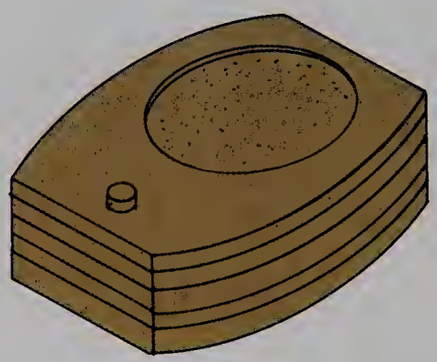
COASTER SET

MODULES COVERED

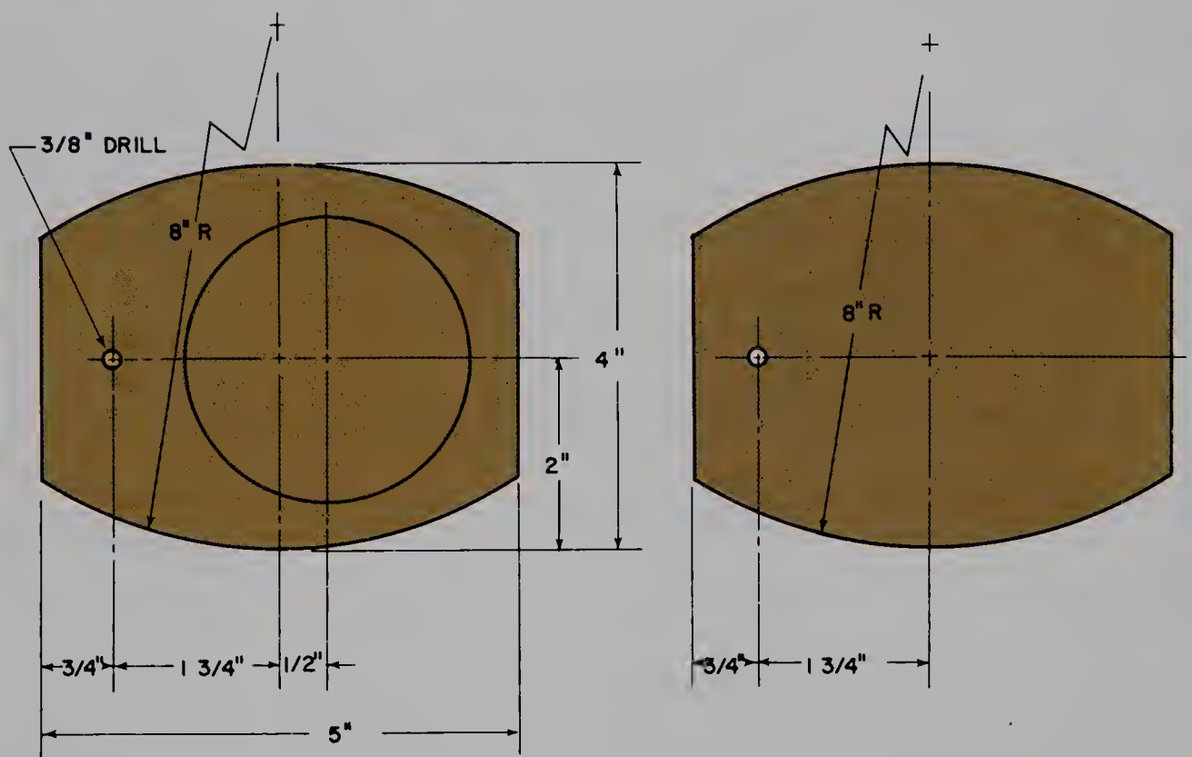
SEPARATING → **ASSEMBLING** → **FINISHING**

- SEPARATING: Cutting, Sanding, Drilling, Shearing
- ASSEMBLING: Adhesive
- FINISHING: Dipping, Brushing, or Wiping



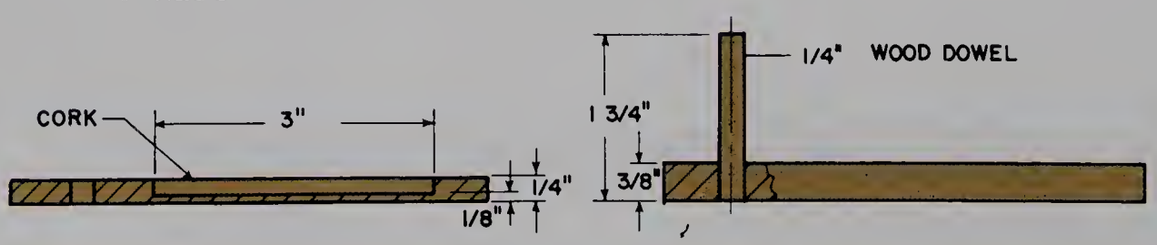


COASTERS



COASTER
4 REQ'D

COASTER BASE
1 REQ'D

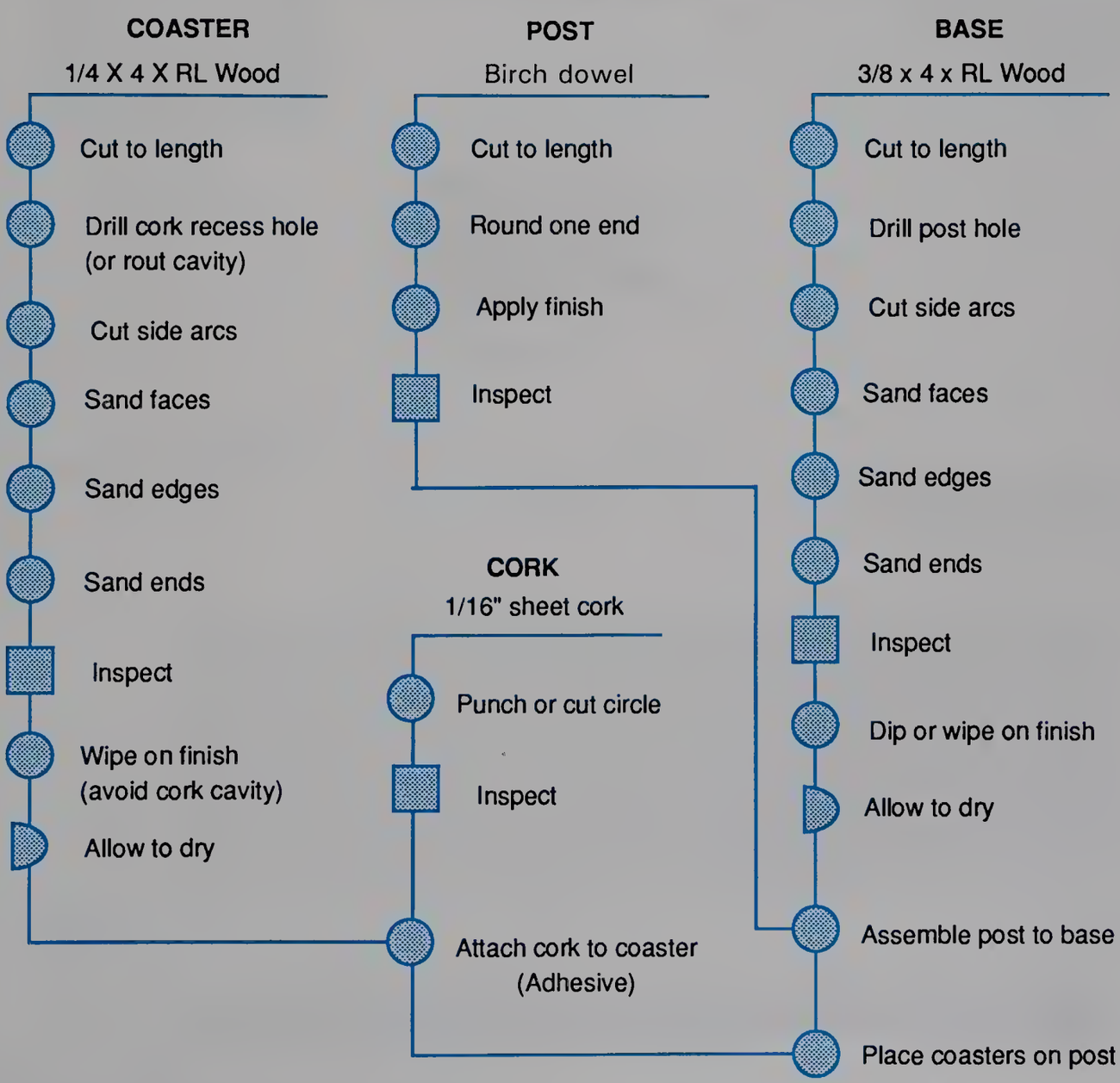


COASTER SET

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
4	Coasters	1/4	4	5	Walnut, maple, or redwood
1	Base	3/8	4	5	Walnut, maple, or redwood
1	Post	1/4 dia		1 3/4	Birch dowel

OPERATION PROCESS CHART



ANTIGRAVITY GAME

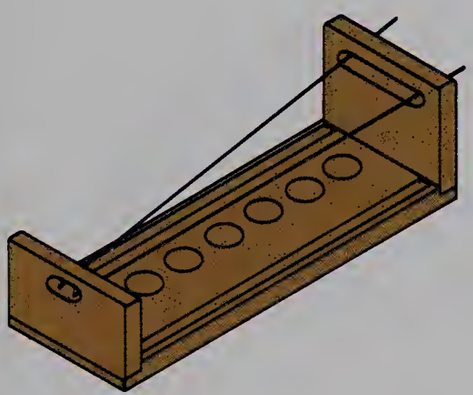
MODULES COVERED

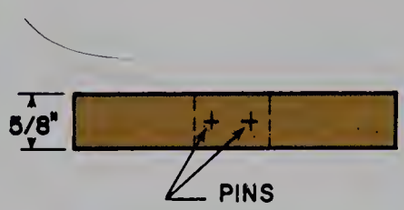
SEPARATING → **ASSEMBLING** → **FINISHING**

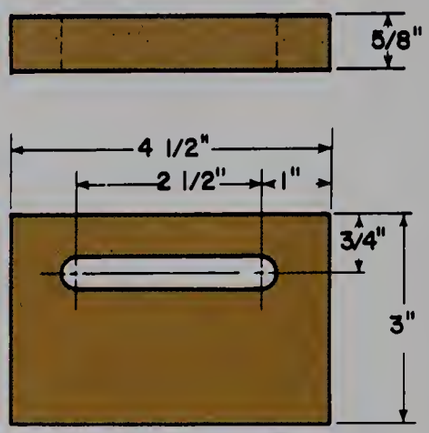
Cutting
Routing
Filing
Sanding
Drilling

Mechanical Fasteners

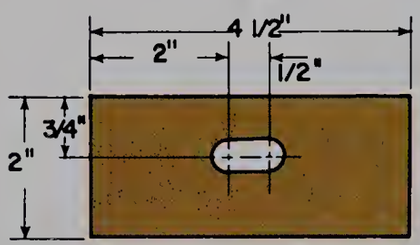
Brushing
or Spraying



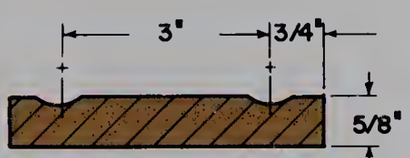




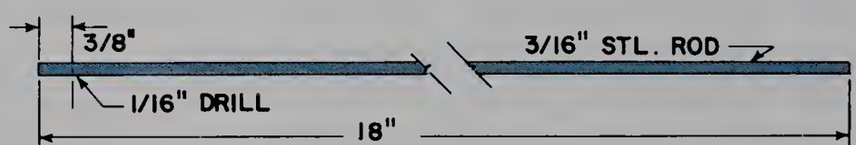
END (LONG)
1 REQ'D

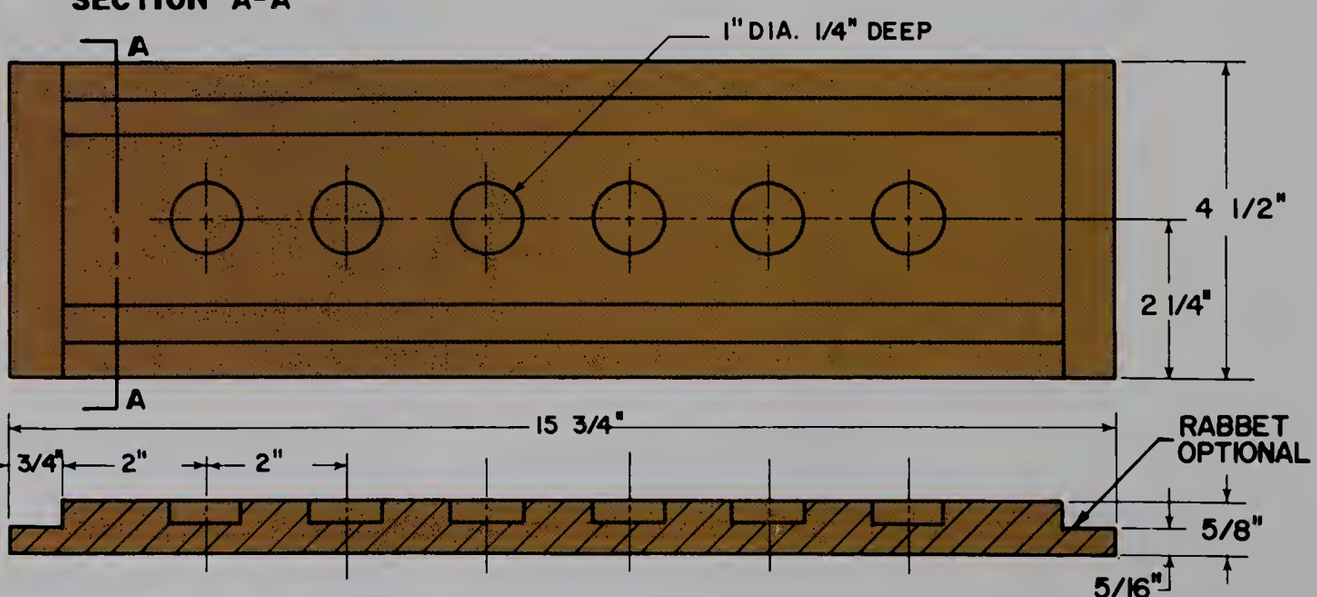


END (SHORT)
1 REQ'D



SECTION A-A



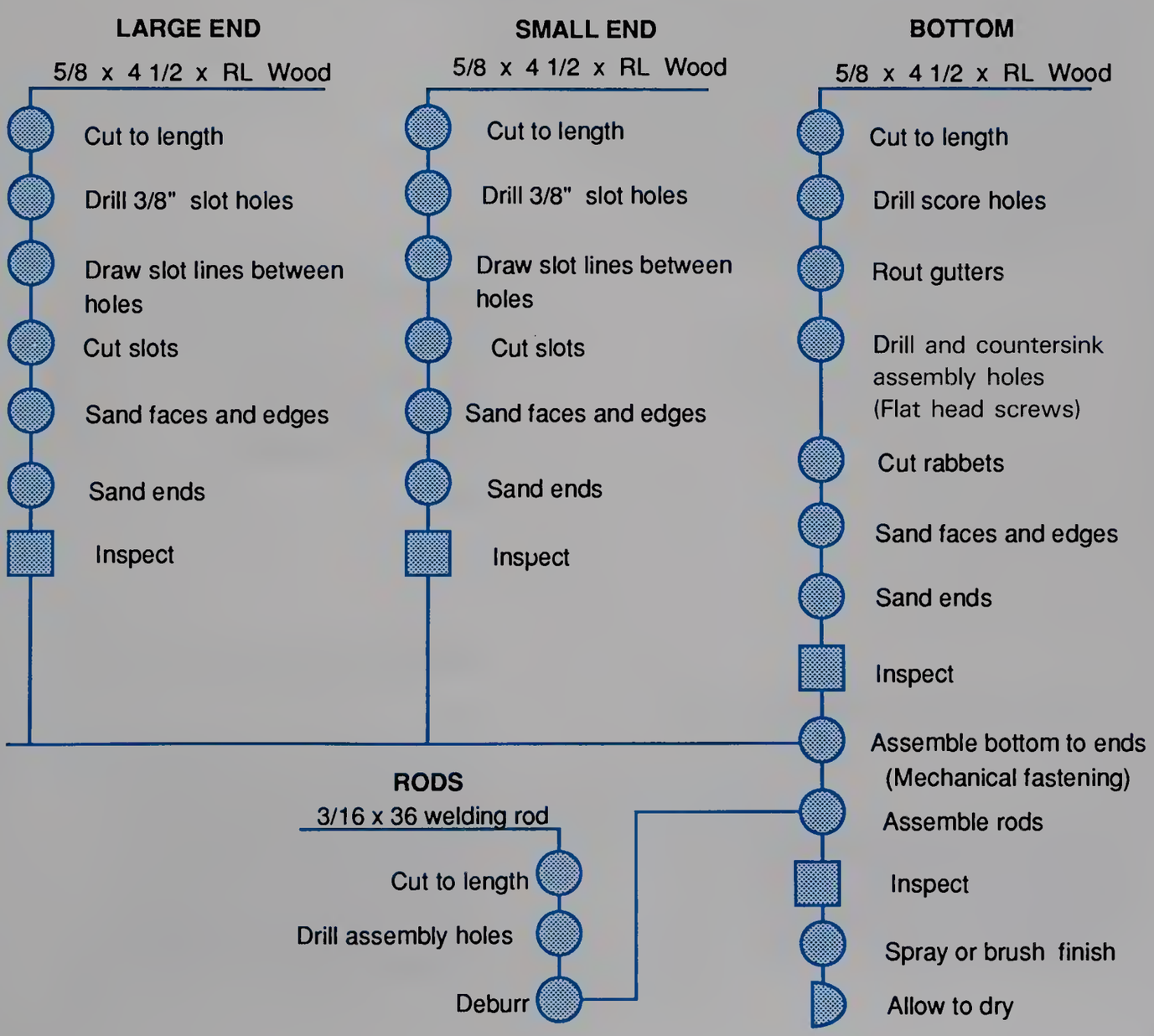


ANTIGRAVITY GAME

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
1	Base	5/8	4 1/2	15 3/4	Redwood or pine
1	Small end	5/8	4 1/2	2	Redwood or pine
1	Large end	5/8	4 1/2	3	Redwood or pine
2	Rod	1/4		18	Welding rod
1	Ball	1 dia			Reject ball bearing

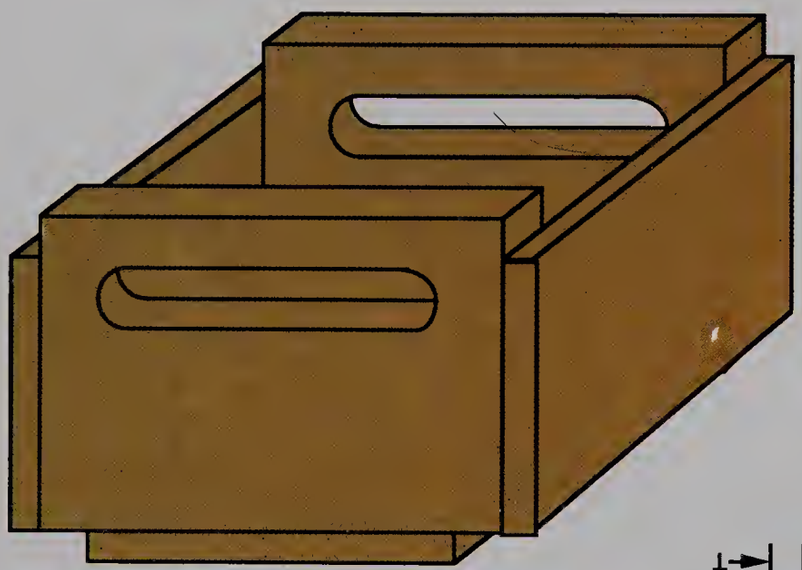
OPERATION PROCESS CHART



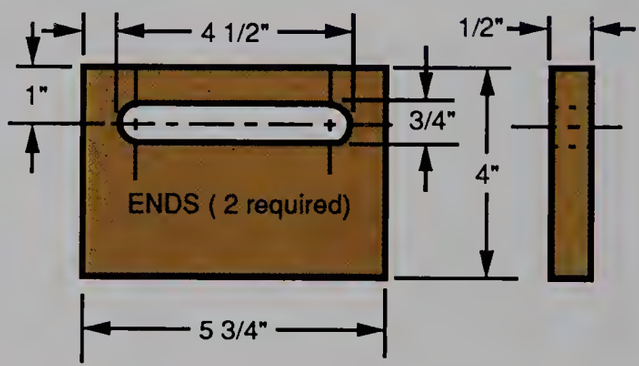
CD HOLDER

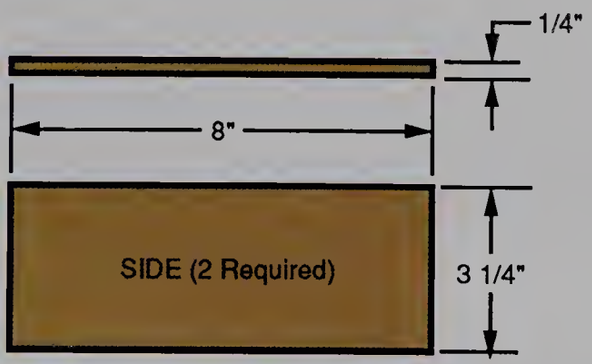
MODULES COVERED

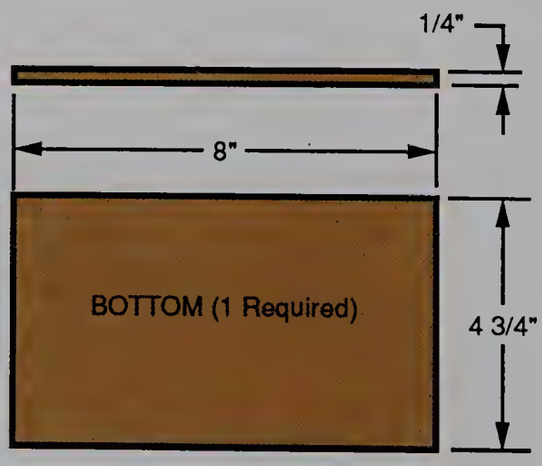
SEPARATING	ASSEMBLING	FINISHING
Cutting Routing Sanding Drilling	Adhesive Mechanical Fasteners	Brushing or Spraying



NOTE: The length of the sides and bottom may be adjusted to hold more or fewer CDs.





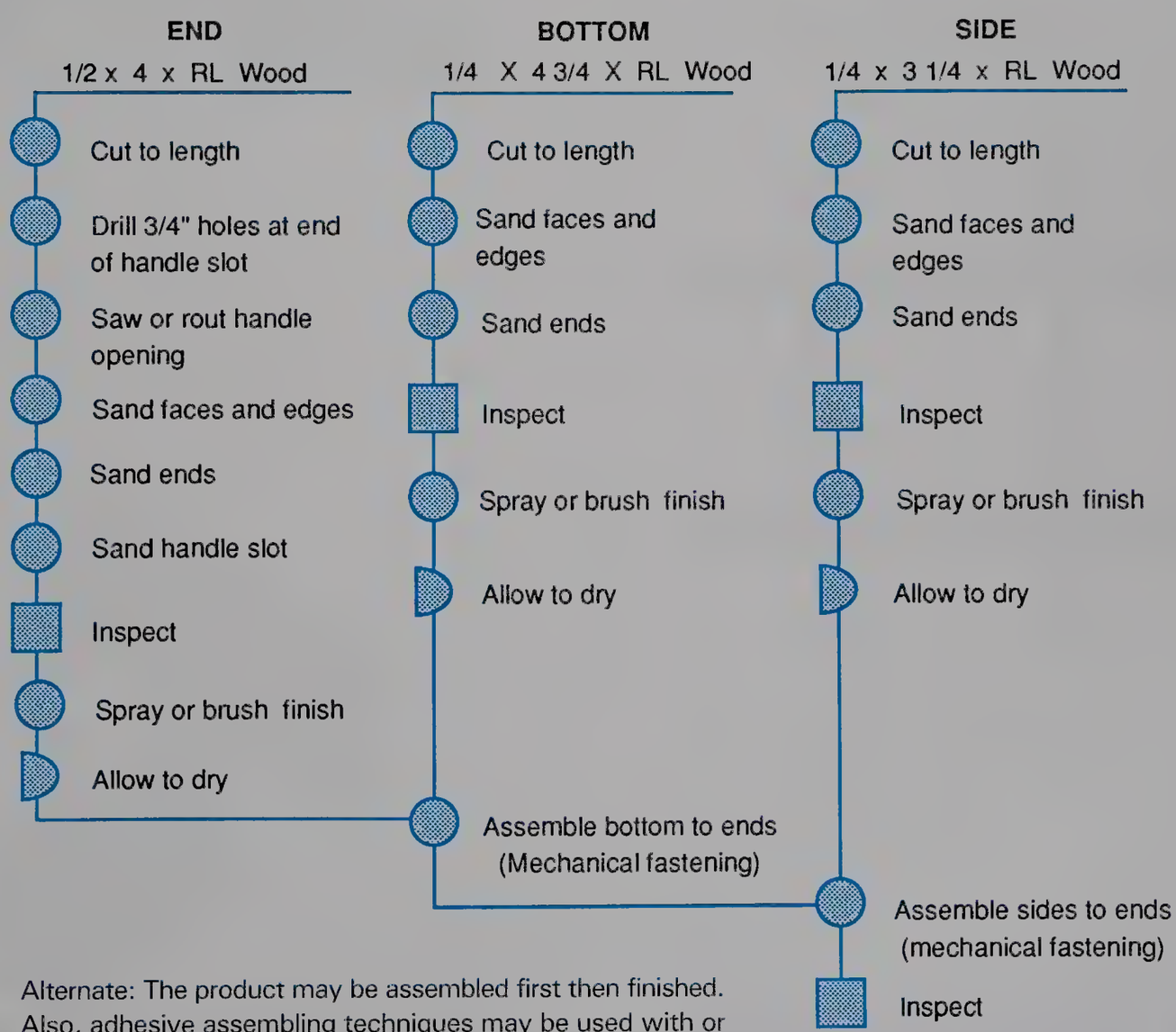


CD HOLDER

BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
2	Ends	1/2	4	5 3/4	Maple, walnut, or pine
2	Sides	1/4	3 1/4	8	Maple, walnut, or pine
1	Bottom	1/4	4 3/4	8	Maple, walnut, or pine

OPERATION PROCESS CHART



Alternate: The product may be assembled first then finished. Also, adhesive assembling techniques may be used with or in place of the mechanical fasteners.

PLANT HOLDER

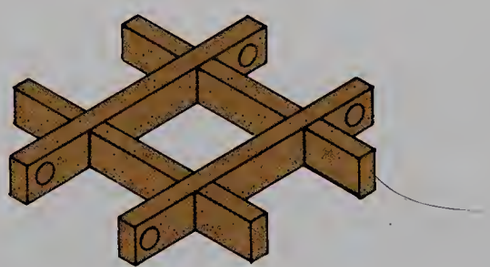
MODULES COVERED

SEPARATING → **ASSEMBLING** → **FINISHING**

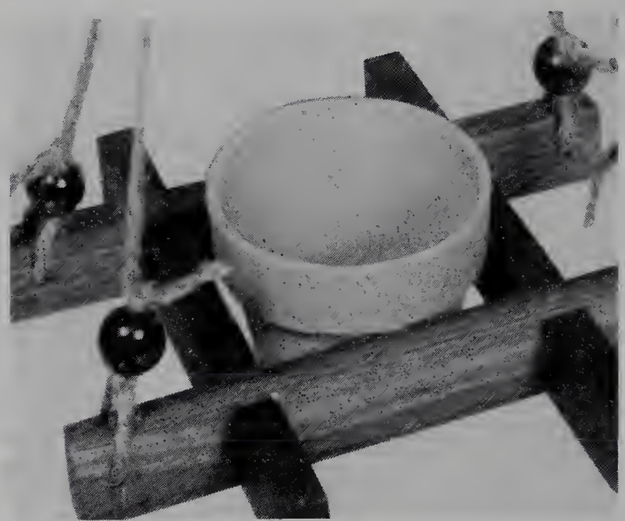
Cutting
Sanding
Drilling

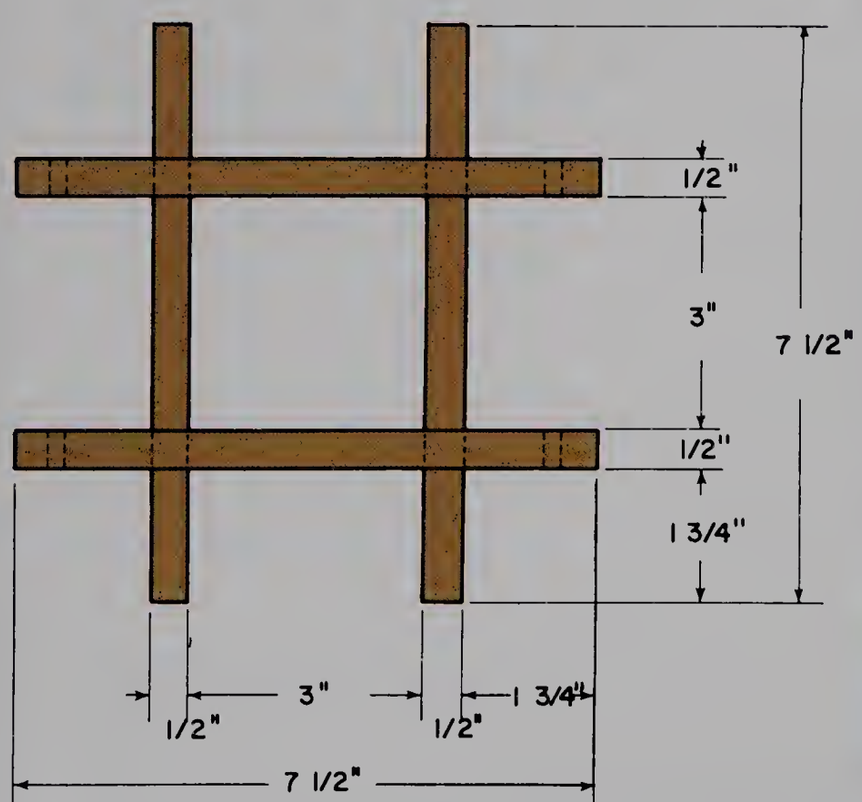
Mechanical Force

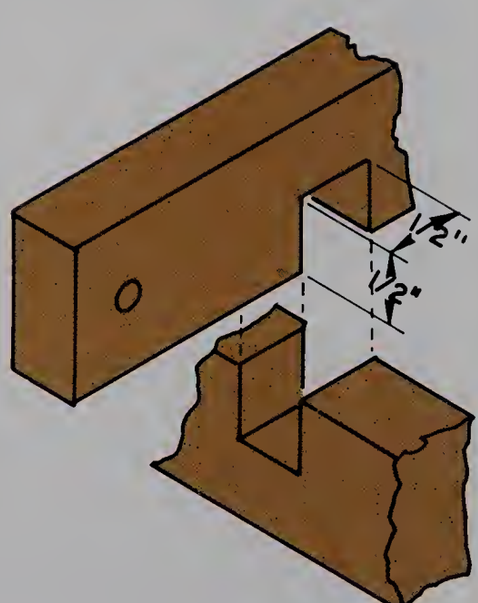
Dipping,
Brushing, Spraying,
or Wiping

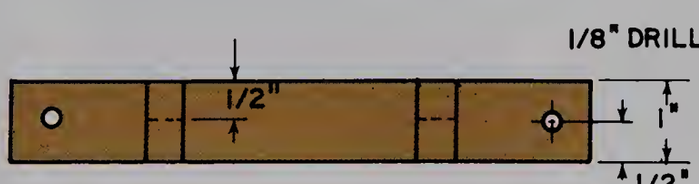


HANGING FLOWER POT—
HANG ON MACRAME CORD









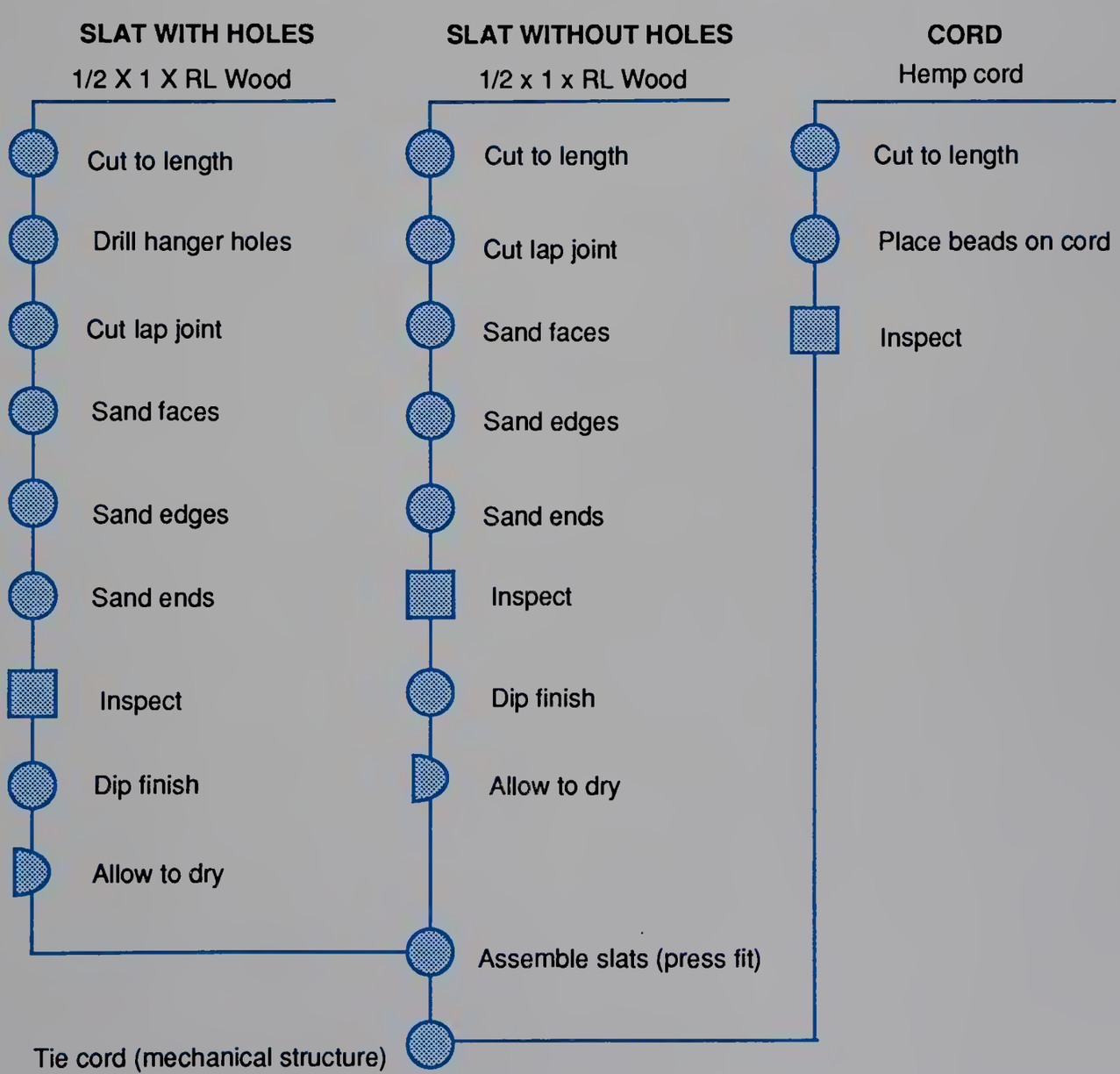
JOINT DETAIL

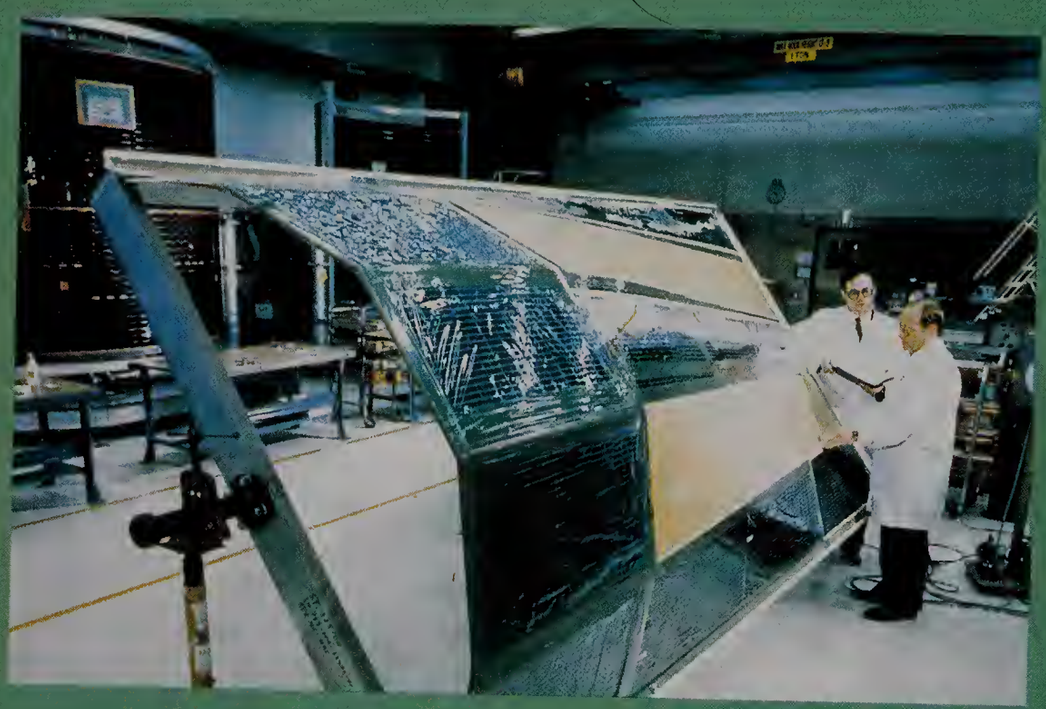
PLANT HOLDER

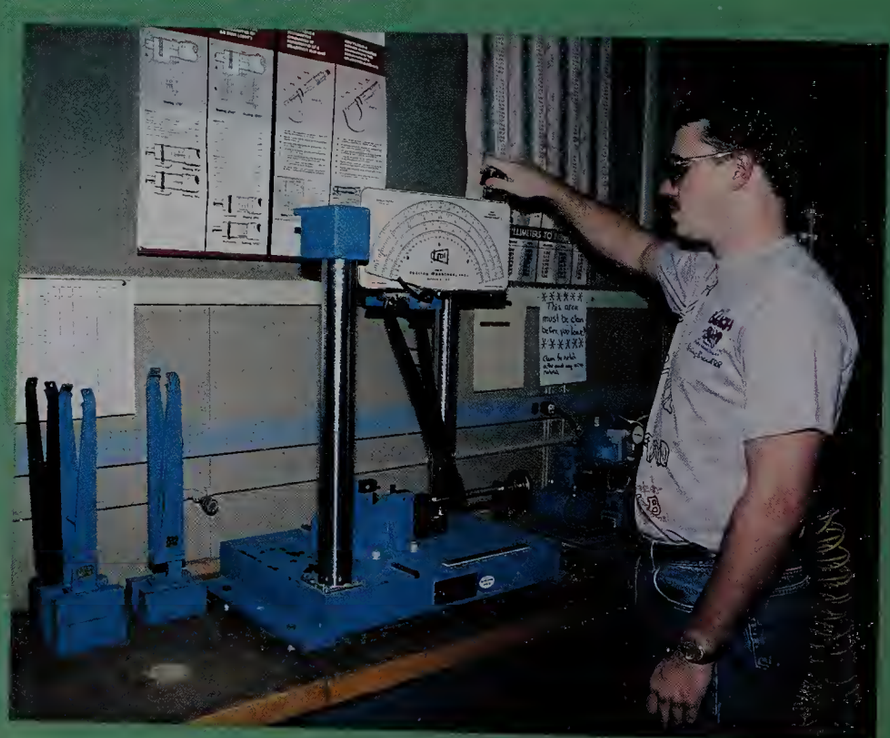
BILL OF MATERIALS

Qty.	Part Name	Size T x W x L			Material
4	Slats	1/2	1	5	Walnut, maple, or redwood
2	Cords			24 - 28	Hemp cord
4	Beads	1/2 dia			Colored wooden beads

OPERATION PROCESS CHART







section 4

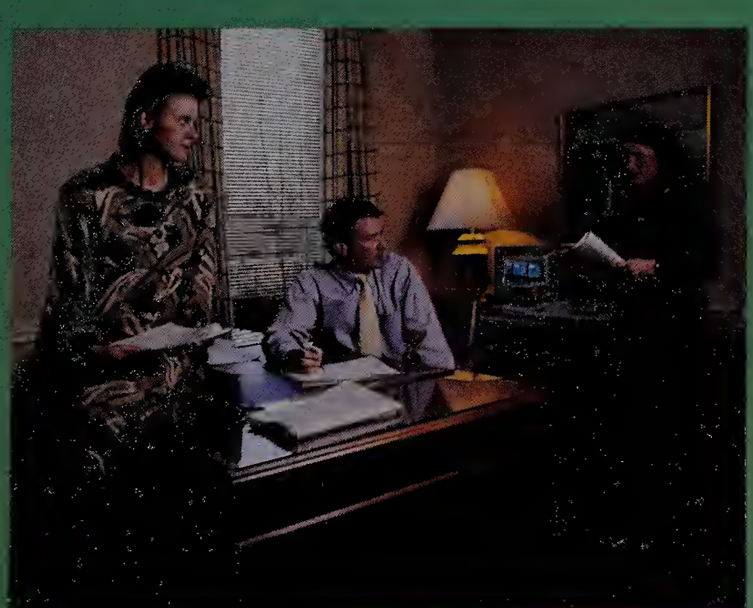
Introduction to Management

13. Entrepreneurship, Enterprise, and Management

14. Company Organization and Structure

15. Managed Product-Centered Activities

16. Managed Support Activities



SONOCO PRODUCTS CO.



MARTIN MARIETTA CORP.



These students are learning about manufacturing systems by participating in an enterprise activity. (Bud Smith)

13

CHAPTER

ENTREPRENEURSHIP, ENTERPRISE, AND MANAGEMENT

After studying this chapter, you will be able to:

- *Describe the characteristics common among entrepreneurs.*
- *Explain how risks, profit, and free enterprise apply to most business enterprises.*
- *List the four major tasks of management.*
- *Name at least four groups to which management is responsible.*
- *Describe five areas of managed activity involved in manufacturing.*

Have you ever wondered how a company comes into existence? It starts with someone who has a new idea, Fig. 13-1. For instance, the idea for Federal Express started with a graduate school paper on the need for quick package delivery. Apple Computers was based on the belief that individuals would use computers as a tool. Just think about the impact this one idea has had, Fig. 13-2.

ENTREPRENEURS

Some people have ideas for new products and services. They also have the drive to develop them. People with these special talents are called **entrepreneurs**. They are willing to take financial risks. They are action-oriented and want to make things happen. They focus their efforts on meeting the needs of their customers. They are challenged by organizing and watching their companies prosper.

BUSINESS PLAN

Entrepreneurs are often called "enterprising" people, Fig. 13-3. They see opportunities and are willing to pursue them. Most entrepreneurs have a vision for their businesses. This vision can be summarized in a **business plan**. The plan can be a formal, written document or an informal collection of information. In any case, a business plan should contain these nine elements:

- A description of the business *idea*.
- A set of *objectives* for the company.
- A description of the *market* to be served.
- A report on the *competition*, describing similar products on the market.
- A *selling strategy* for the product.
- An analysis of *production costs* and *selling prices* for the product.
- A *production plan* for the product.



Fig. 13-1. Entrepreneurs of all ages and backgrounds start companies with bright ideas and the drive to develop them.

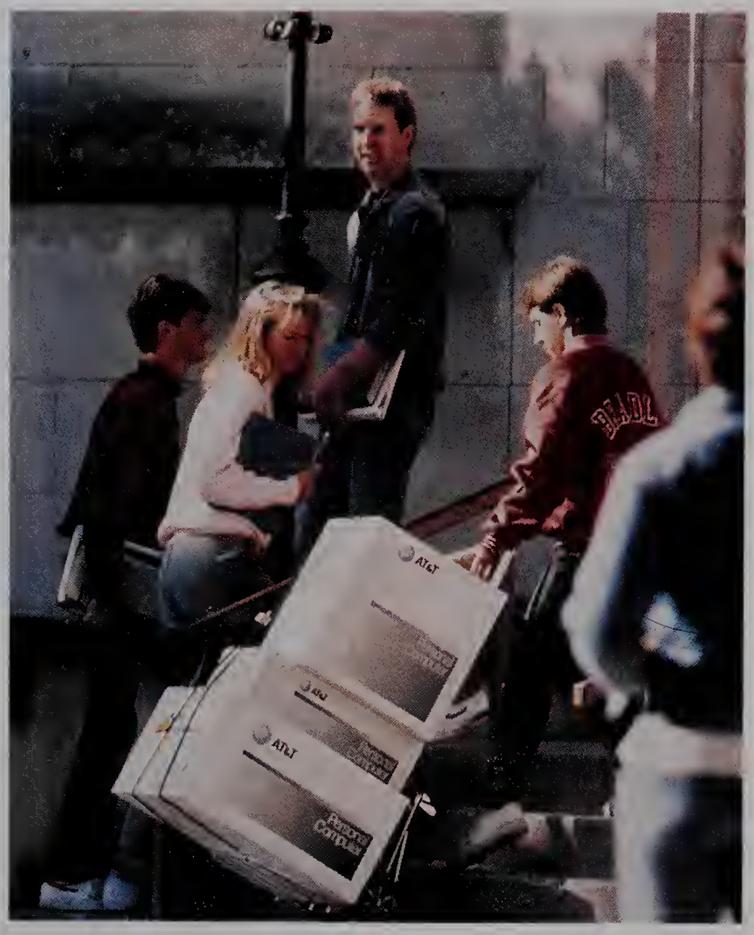


Fig. 13-2. The personal computer industry has grown to such an extent that most people have access to a computer. (American Telephone and Telegraph Co.)

- A *financial plan* to support the company operations.
- A *time schedule* for developing, manufacturing, and marketing the product.

INTREPRENEURSHIP

There is another way in which entrepreneuring people can express their entrepreneurial abilities without the risk of starting a new company. The spirit for developing a company does not always start a new enterprise. Many companies are currently changing their focus. They are encouraging their employees to take risks. They want new ideas and suggestions for improving the company. They also want people to apply their entrepreneurial spirit. A new term has been coined for this focus in existing companies. It is called intrepreneurship (entrepreneurship inside an existing business). Employees who are encouraged to take some of the risks with the company's money, as if they owned the company, are called **intrepreneurs**.

ENTERPRISES

An **enterprise** is a business. It is a unit of economic organization or activity. The result of entrepreneurship is an enterprise. There are enterprises of all sizes

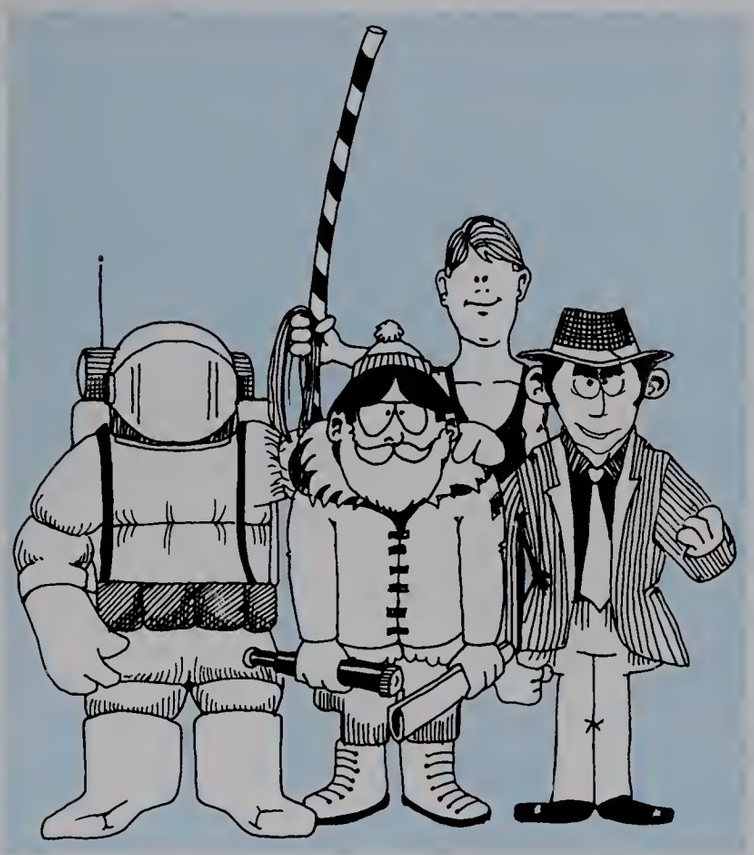


Fig. 13-3. These are all enterprising people. What kinds of businesses do you think they might start?



Fig. 13-4. Enterprises come in all sizes, from small, locally-owned businesses to huge, national companies.

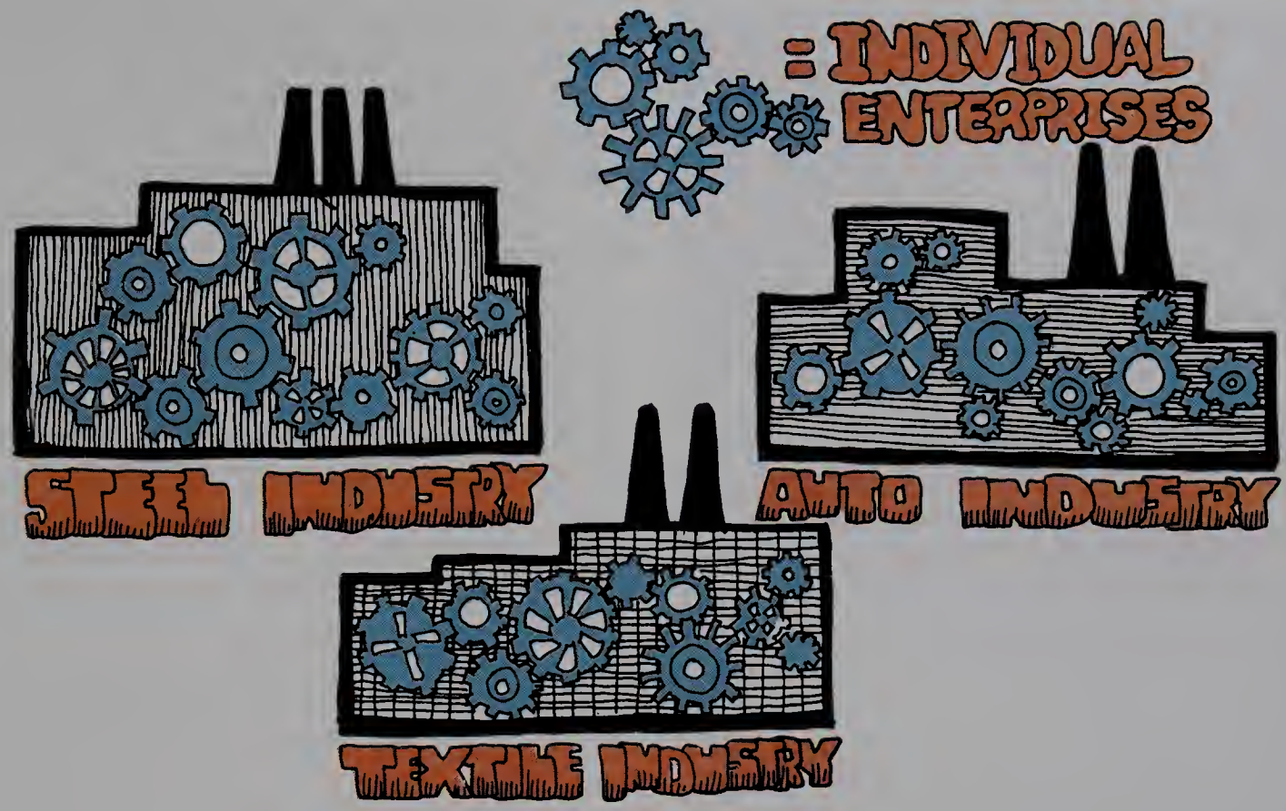


Fig. 13-5. An industry is made up of a series of companies that make similar products and compete with one another.

and types, Fig. 13-4. An enterprise may be a local dry cleaner or pizza parlor, or it may be an economic giant such as General Motors or Sears, Roebuck, and Co. Enterprises are referred to by a number of different names, including *companies*, *firms*, *establishments*, and *corporations*.

Recently, the Department of Commerce reported that there were over 12 million business enterprises in the United States. Nearly 25 percent of these were contractors in the construction industry. About 20 percent were retail merchants. Only slightly more than 400,000, or 3.5 percent, were manufacturing companies. Tough few in number, these companies produce nearly all the products made in America.

You will note that the word, **industry**, is not used to describe an enterprise. This term, when properly used, describes a series of enterprises that make similar products. Examples of these include the automobile industry, the forest products industry, and the food processing industry. Each of these industries is made up of a number of competing business enterprises, Fig. 13-5. Their products are similar or can be substituted for one another.

Some common words describe most business enterprises. These terms include:

- Risk.
- Profit.
- Free enterprise.

RISK

All of life is a risk. If you walk to school, you risk being hit by a car. The risk is not great, but it exists. Likewise, enterprises face risks. The entrepreneur often gives up a secure job to start a company. He or she risks losing money and other personal possessions. The level of risk varies from enterprise to enterprise. See 13-6. There is no guarantee of success. In fact, over 50,000 commercial (wholesale and retail merchants) and industrial companies fail each year. This number grows dramatically during periods of economic downturn.

PROFIT

Few people are willing to take risks without a goal. A quarterback may call a risky play to save the football team from defeat. A person may rush into a burning building to rescue a trapped child. Likewise, entrepreneurs are goal-driven. They like challenges and often "play the game" for the "sweet smell of success." The challenge and winning may be enough, but usually there is more. The success of a company is often measured in terms of profit. **Profit** is the amount of money that is left after all business expenses are paid. It indicates whether or not the company was able to compete with established firms in



Fig. 13-6. Developing a new product like this sun-powered car could be a risk to a company. It also offers the opportunity for financial rewards. (General Motors Corp.)

the marketplace. It determines whether or not the company developed a product that people wanted.

To some people, profit is a negative term, but it shouldn't be. It is simply the reward for taking a risk. You may have money in a savings account. You profit from allowing the bank to risk your money on car or home loans. They pay you interest (a portion of their profits) for the risk you took. Likewise, the entrepreneur or the owners of the company share in both the risks and the successes of a company.

How large can a company expect profits to be? A recent study asked people this question. The answers covered a wide range. The average estimate was about 30 percent of each sales dollar. This should be compared with the actual return of about six percent for manufacturing companies. Granted, some make much more than this figure, and some don't make any profit at all.

On average, some types of companies, such as those in pharmaceuticals and computer electronics, make a great deal more profit than other companies. Some make considerably less, such as those in meat packing and apparel manufacturing. Some companies are in higher risk areas or require much more initial money to operate. Successful companies in these areas generally earn higher profits than those in low-risk, low-capital operations.

FREE ENTERPRISE

Many Western societies were built on the idea that business should be conducted through privately owned companies. This is called the **free enterprise system**. In this system, the vast majority of economic activities are conducted by profit-centered companies. They must compete for business, for employees, and for natural resources. The marketplace establishes the selling price for their products, the wage rate for their workers, and the purchase price for their material inputs.

Free enterprise allows companies to operate with a minimum amount of governmental control. Only selected segments of the economy are government owned or regulated. These segments provide services that are so essential that public ownership is desirable. They also provide services when the costs make unregulated private ownership unwise.

Consider the police force. What would happen if it was privately owned? See Fig. 13-7. It would have to show a profit at the end of each year. It could only serve those customers who could afford the services. How about the fire department? It would have to analyze the cost effectiveness of fighting fires. Only expensive buildings could be saved. It is in the public interest to make police and fire fighting decisions on factors other than profit.



Fig. 13-7. Imagine what would happen if the police department were run for profit.

Likewise, it would not be economically wise to allow several companies to supply electrical power in a community. Think about how expensive it would be to have three sets of power lines in every community. Many extra meter readers and repair crews would also be needed.

Many activities need market control. The consumers of products and services need a strong voice in company operations. You make your voice heard every time you buy one product and pass up competing products. Ask an older person about 8-track tapes, 78 rpm records, Shinola shoe polish, and DeSoto automobiles. Low sales volume caused each of these to disappear from the market.

In a free enterprise system, failure to meet customer expectations means losing money. This means going out of business.

Some countries use central industrial control. A government official decides what is to be manufactured. The production quantities are set by bureaucrats. For instance, suppose you want to buy a winter hat. All that may be available are felt hats, whether you want them or not. Refusing to buy them would have very little impact on the availability of goods in such an economy.

MANAGEMENT

Management is the collective body of those who manage or direct an enterprise. It is the act of conducting or supervising a business. The responsibility for operating a company rests with its owners. This works fairly well with small businesses that have only a few owners. However, very large companies may have hundreds or thousands of owners. Most of these people do not want to run the company. They may also fail to have the ability to direct the company's operations. This is why the owners employ professional managers to oversee their interests, Fig. 13-8. To understand management, you must consider three factors:

- Functions.
- Responsibilities.
- Areas of activity.

FUNCTIONS OF MANAGEMENT

Management involves a process that continuously addresses four major tasks. These tasks or functions, as shown in Fig. 13-9, are:

- **Planning:** Setting goals and major course of action to reach them.
- **Organizing:** Developing a structure to reach the goals.
- **Actuating:** Assigning tasks to specific employees or groups and encouraging them to complete the work.
- **Controlling:** Comparing actual results to the plan.

You can view this as a four-step process from goal setting to task completion. This is a proper view for jobs with an definite end. For example, if you bake a cake, this model would work. You would complete each step only once. First, you would *plan* or set a



Fig. 13-8. Professional managers oversee company operations. (Hon Industries)



Fig. 13-9. The management process involves planning, organizing, actuating, and controlling.

goal. You might say, "A chocolate cake would sure taste great for dessert." Then you would *organize* the task. You would gather the ingredients and utensils needed to bake the cake. *Actuating* would follow. You would have to mix the batter, place it in a pan, and bake the cake. Finally, you would exercise *control*. You would decide if you met your original goal. Did the cake taste good? Was it ready in time for dessert? When you accepted the results, you would be finished.

However, few manufacturing companies work on one-time projects. They are constantly trying to become more efficient, develop new products, or improve old ones. Therefore, managers and workers constantly replan, reorganize, and reactuate operations. Each of these actions are constantly evaluated or subjected to control.

All four of the managerial functions are in operation all the time, Fig. 13-10. A new plan may be developed. A goal of fifty products per hour may be revised to sixty per hour. Production operations may be reorganized. New management systems may be introduced as a better way to actuate work. In short, the process is never complete. Goals are not permanent. Organizations change as products and competitive forces change.

Change is the one constant in modern industry. The survival of any company depends on its ability to change. Individual workers must change to maintain their jobs. New products must be developed. Old ways of doing things must give way to new techniques. Remember, the future isn't what it used to be. People should expect change, welcome change, and grow with change.

Planning

Planning is the foundation of success. It provides a goal and gives direction. Planning gives company personnel a clearer vision of the goals to be achieved. Planning, as shown in Fig. 13-11, involves at least four major steps:

1. *Gathering information:* A plan is based on knowledge. Managers must have many types of information before they set goals for the company. This information should include data about materials and processes, customer needs and wants, financial demands, money availability, employee skills, equipment availability, and competition.
2. *Arranging the information:* Once the information is gathered, it must be studied. Trends must be established. Valuable information must be separated from the data that isn't useful or necessary.
3. *Developing alternatives:* All challenges facing management have alternative solutions. There is more than one way to meet a need or want. More than one process can be used to accomplish a

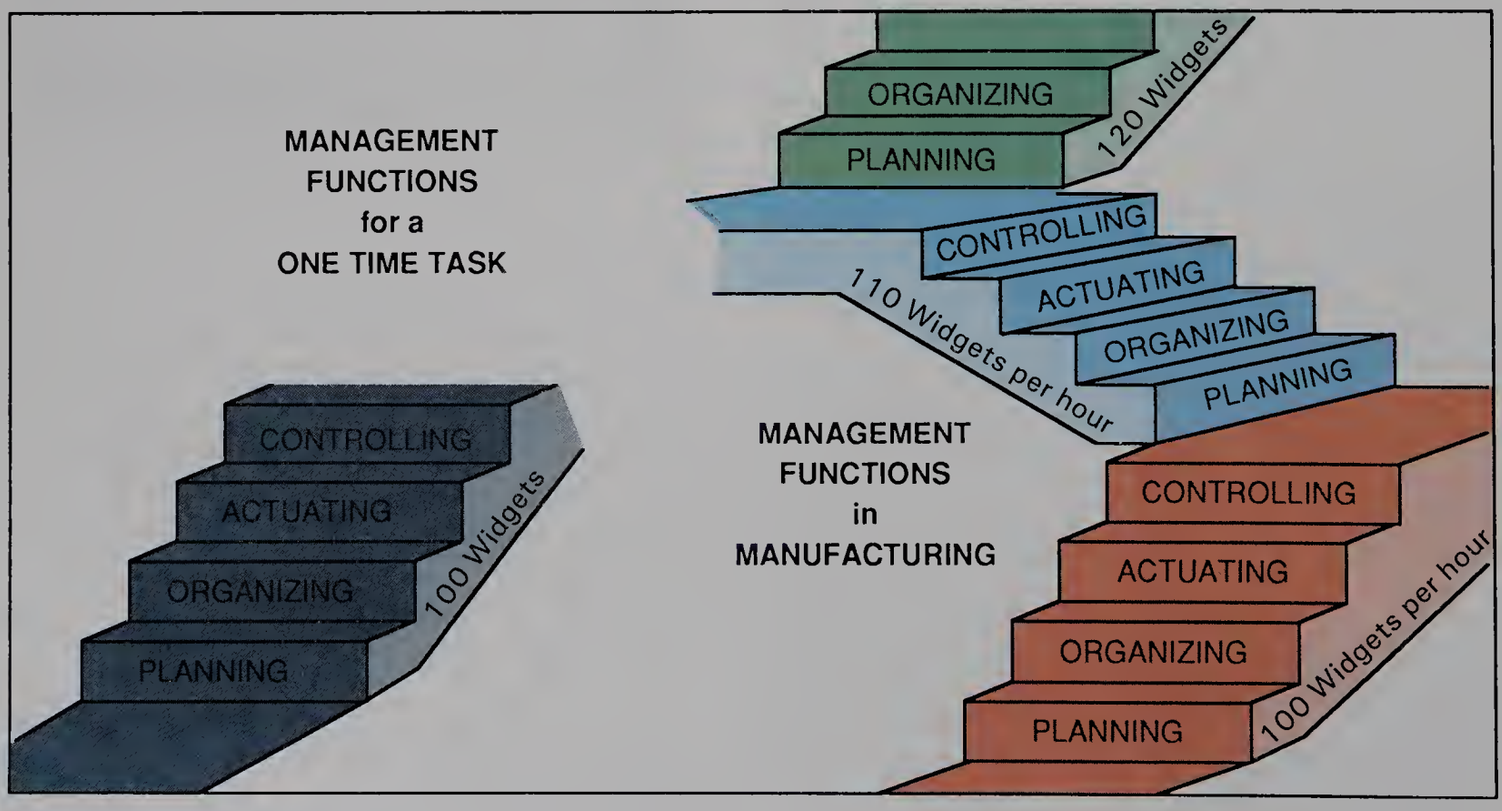


Fig. 13-10. In most companies, managerial functions are in action all the time.

task. Managers should develop as many solutions as time permits.

4. *Selecting a course of action:* From the alternative solutions, a "best" solution must be selected. Each alternative solution must be analyzed in terms of several factors including cost; customer acceptance; technical feasibility; profitability; and material, equipment, and personnel requirements. The selected solution will likely be a compromise. The solution should be the answer that meets as many criteria as possible.

Organizing

It is important to establish authority and responsibility for every task. For example, you may be responsible for keeping the garage clean. How much authority do you have over people using the garage? Can you insist that family members pick up tools, bikes, and other items they use? If not, you have responsibility without authority.

Effective managers know that each job must be assigned appropriate authority to support the responsibility. Also, resources must be allocated to the task. Equipment, personnel, and materials to do the job must be available. The job of assigning responsibility, authority, and resources is called organizing, Fig. 13-12. The company's resources should be structured to insure that the selected goals are reached.

Actuating

People complete tasks every day. You may have taken out the garbage. To do that job correctly, you needed to know what was expected of you. Then you had to be motivated to do it. You may have done the job because you wanted to be part of the team–the family. You may have done it because you like neat surroundings, or you may have been ordered to do it.

People who want to do a task often do the best job, Fig. 13-13. A person is more likely to approach a task with a positive attitude if he or she:

- Knows how to do the job.
- Sees the task as important.
- Receives recognition if the job is done well.

People become motivated workers when these factors are present. The task of actuating helps to insure that the job is done well. This does not necessarily



Fig. 13-11. Planning follows four logical steps.



Fig. 13-12. Through organizing, managers decide who is to do what task, with how much authority, and with what resources. (Nevada Power Co.)



Fig. 13-13. Workers are more likely to develop positive attitudes toward the job and the company if they know what is expected and why it needs to be done. (AMP Inc.)

mean telling people what to do. In the best situations, it means helping people do their work. It means facilitating action, encouraging people to do their best (being a cheerleader), and rewarding people for a job well done.

Controlling

All activities produce results. The job of controlling is to insure that the results closely match the plan. A manufacturing company uses many types of control. Quality is controlled. See Fig. 13-14. Production is controlled. Expenses are controlled.

To maintain proper control, managers and workers must:

1. Continually compare performance with the business plan.
2. Determine if corrective action is needed.
3. Decide what corrective action is needed.
4. Take the necessary corrective actions.

Control does not always mean changing actions to meet plans. In some cases, the plan needs to be revised. Unexpected events may make the original plan impractical. An unexpected increase in raw material costs may make the original budget impossible to meet. A new, competitive product may make original sales projections unrealistic. In other cases, control activities may uncover improper planning, poor organizational structures, or inadequate direction. Then corrective action is needed.

RESPONSIBILITIES OF MANAGEMENT

Managers are often pictured as greedy, profit-chasing people. The Ebenezer Scrooge model is often not a fair picture of management, Fig. 13-15. Managers have a complex task of meeting the demands of many groups. They have responsibilities to at least four groups. These include the:

- Owners.
- Employees.
- Customers.
- General public.

Management's responsibilities to the owners

A company must make a profit to stay in business. Unprofitable companies cannot pay wages to em-



Fig. 13-14. This worker is visually inspecting a printing plate. This is part of a quality control program. (Graphic Arts Technical Foundation)

ployees, buy materials from suppliers, pay taxes to governmental units, or attract investors.

Companies need money to make money. Many companies must convince people to buy shares of the company, Fig. 13-16. However, people will invest money only if they expect to receive a reward. This reward is a share of the company's profit and ownership in a growing enterprise.

Therefore, managers must run the company to make a profit. They must show that the trust given to them was well placed. They must wisely and honestly invest the owner's money in safe and profitable activities.



Fig. 13-15. Managers of companies are not necessarily like Ebenezer Scrooge. They have conflicting responsibilities to several groups.

Management's responsibilities to employees

Wise managers are concerned about the welfare of their employees. Employees are the people who put a portion of their lives and labor into the company. In return, employees have a right to expect:

- Fair wages.
- Steady employment.
- Opportunities for advancement.
- Pleasant and safe working conditions.

These benefits can only be provided if the company is profitable. The chances for profitability are increased if management shows genuine concern for the workers.

Management's responsibilities to customers

The primary purpose of a manufacturing enterprise is to produce products that meet the needs and wants of customers. The workers and managers can work together to produce products. However, if customers fail to buy them, the company will fail. Successful companies provide customers with functional products at a fair price, Fig. 13-17. They

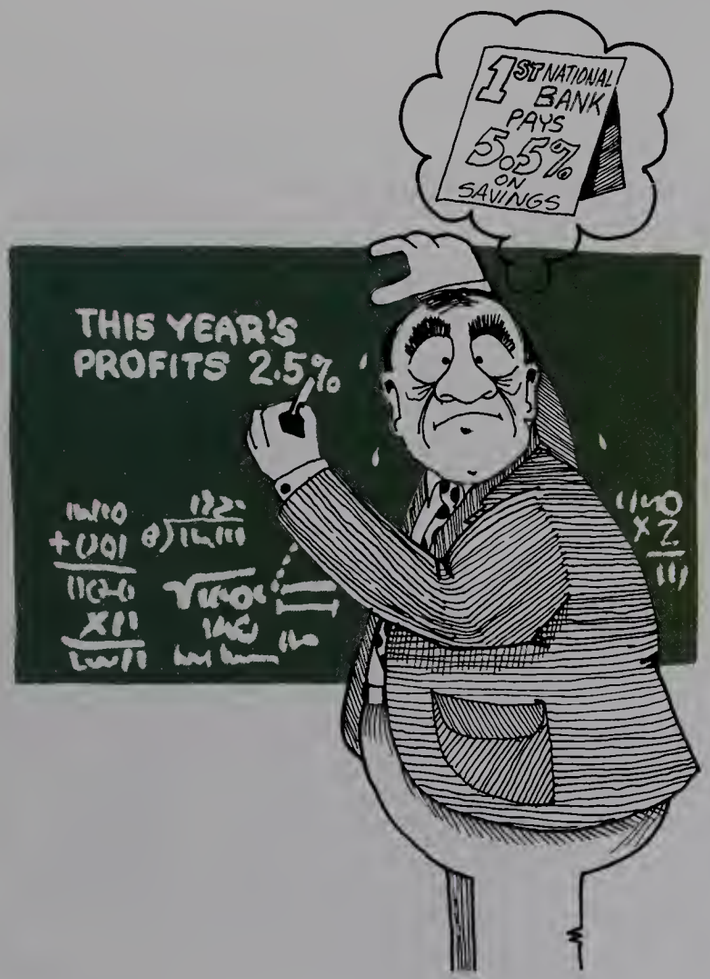


Fig. 13-16. Low profits could cause investors to consider other ways to invest their money.



Fig. 13-17. The customer expects products to be priced fairly and to work as well as the manufacturer says they will.

follow the sale with maintenance and service. They also listen to the customer as they develop new and improved products.

Management's responsibilities to the general public

Managers of manufacturing companies are expected to be good citizens. They are expected to be honest, pay their taxes promptly, and contribute to the community. Company managers are expected to be concerned about the environment. They are also expected to provide employment, contribute to community projects, and provide personnel for volunteer agencies.

AREAS OF ACTIVITY

A manufacturing enterprise is a factory-based, profit-centered organization. It uses various resources to convert materials into products. The word *manufacture* comes from the Latin words, *manus* (hand) and *facere* (to make). At one time, to manufacture meant to make a product by hand. Today, few products are handcrafted. They are produced by complex systems in which people use machines to convert materials into products. The system uses a combination of human abilities and machine processing, Fig. 13-18.

All manufacturing systems include a number of managed areas of activities. These activities convert a designer's insight ("This would make a great product!") into a marketed product ("I could really use that product!").

Manufacturing managers see that a number of activities are successfully carried out. These include:

- Designing and engineering products.
- Developing production systems.
- Securing human, capital, and financial resources.
- Changing materials into products.
- Promoting and selling products to customers.
- Maintaining positive relations with workers and the public.

These activities may be grouped under five major areas, Fig. 13-19. Three of the activities directly move the product from an idea to a profit. They are research and development, production, and marketing. They are directly related to the product.

The other two activities support the product-centered activities. They deal with human and financial activities. These activities are industrial relations and financial affairs.

All five managed areas of activity are briefly introduced below. They will be discussed at length in Chapters 15 and 16. See Fig. 13-20.

- **Research and development:** The activity area concerned with developing products and the processes needed to produce them.
- **Production:** The activity that engineers the system to produce products and then produces products to stated quality standards.
- **Marketing:** The activity that promotes, sells, and distributes the company's products and services.





Fig. 13-18. Modern manufacturing integrates human abilities with machine processing. (Federal Industries)

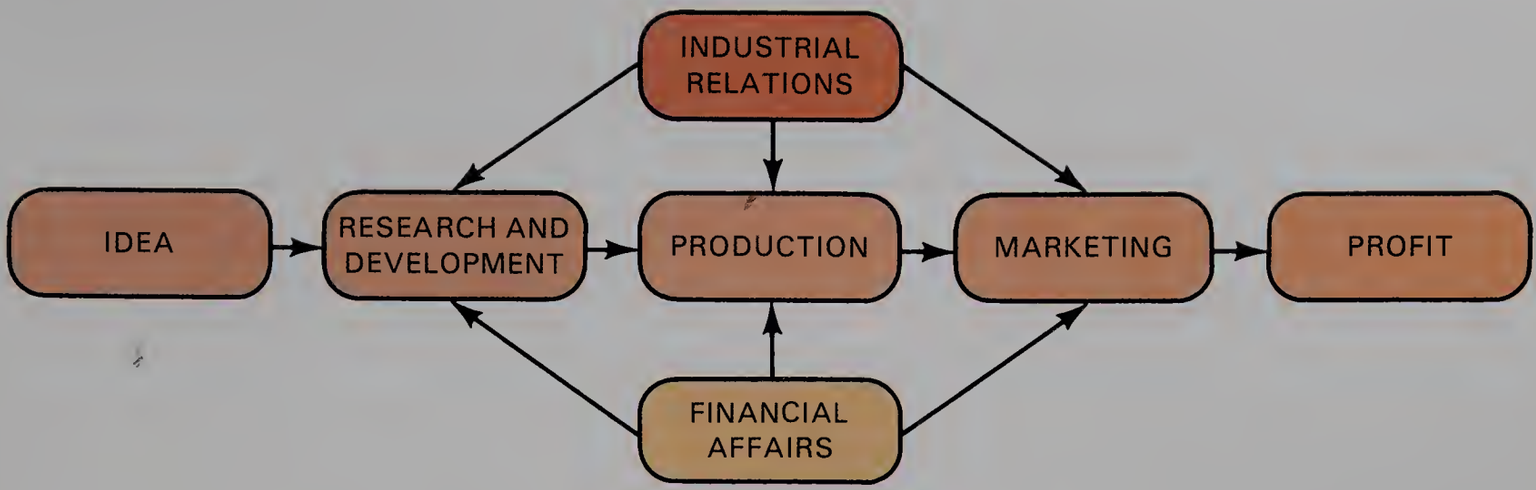


Fig. 13-19. The managed areas of activity in a manufacturing enterprise change ideas into profits.

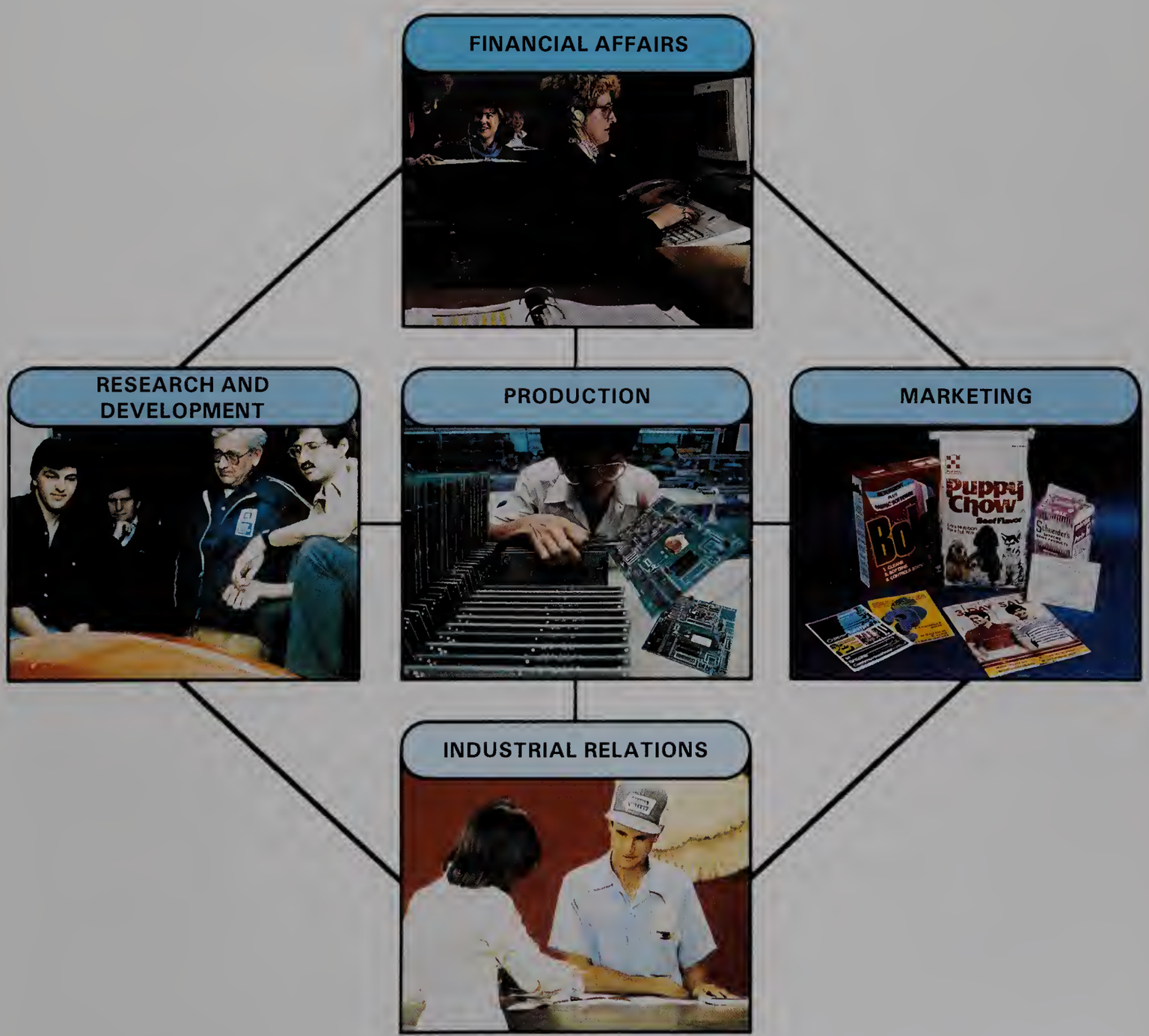


Fig. 13-20. These are the managed activity areas involved in manufacturing. (Exxon, Hon Industries)

- **Financial affairs:** The activity that raises money, accounts for its use, and purchases the goods and services needed to operate the company.
- **Industrial relations:** The activity that strives to keep the relations between the employees, public, and management positive.

SUMMARY

Manufacturing companies often start with a product idea in the mind of an entrepreneur. This person is a risk taker and a hands-on manager. From his or her work, an enterprise grows. This enterprise must be managed. Activities must be planned. Resources must be organized. People must be trained and encouraged to produce quality work. The results of the activity must also be compared to the original plan.

Management is carried out through five major activities: research and development, production, marketing, financial affairs, and industrial affairs. Through these activities, a product idea moves from the designer's mind into reality.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

actuating
business plan
controlling
enterprise
entrepreneurs
financial affairs
free enterprise system
industrial relations
industry
intrepreneurs
management
marketing
organizing
planning
production
profit
research and development

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Describe the characteristics an entrepreneur should possess.
2. List nine items that should be included in a business plan.
3. Which of the following is an example of a business enterprise?
   a. Sears, Roebuck, and Co.
   b. General Motors.
   c. A local pizza parlor.
   d. All of the above.
4. _____ is the amount of money that is left after all business expenses are paid.
5. Which of the following is an example of a free enterprise?
   a. The local fire department.
   b. The local police department.
   c. The local grocery store.
   d. All of the above.
6. List the four major tasks of management.
7. Name the four steps involved in planning.
8. Managers have responsibilities to:
   a. Owners.
   b. Employees.
   c. Customers and the general public.
   d. All of the above.
9. True or False? The chances for profitability are increased if management shows genuine concern for the workers.
10. List and describe the five managed areas of activity involved in manufacturing.

APPLYING YOUR KNOWLEDGE

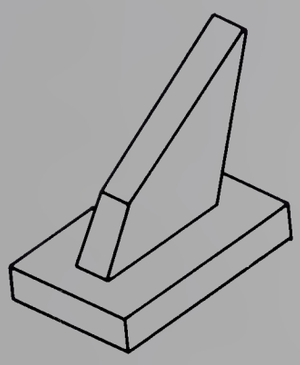
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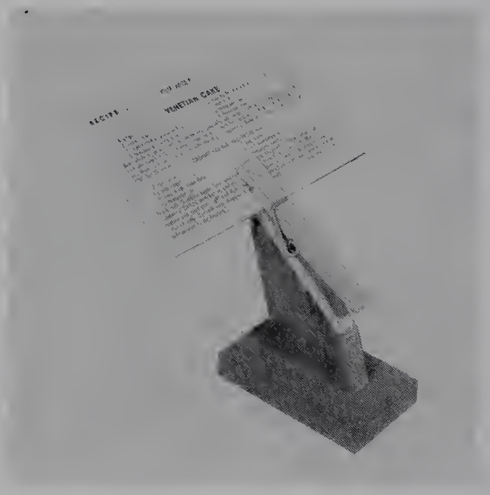
1. Assume that you want to start a lawn mowing business. Prepare a brief business plan for the enterprise.
   a. Describe your idea for the business.
   b. List all the things you hope the business will accomplish.
   c. What kinds of people will use your service and where are they located in relation to your home?
   d. List all other lawn services that might compete with you for the same customers. Describe how you will compete with them.
   e. Develop a plan for selling your service to customers.
   f. Determine your costs and work out a plan for covering costs and making a profit.
   g. Describe how you will finance your service until it begins paying for itself.
   h. Set up a work schedule that will meet the needs of your customers without interfering with your classes or your home chores.

2. Assume you have been assigned a term paper to write. On a chart, like the one in Fig. 13-A, list the planning, organizing, actuating, and controlling activities that will be needed in order to complete the term paper.
3. The class will be divided into two groups. One group will use a production line, while the other group uses custom manufacturing techniques to manufacture a product like the one shown in Fig. 13-B. (This activity will extend over the next three chapters.)

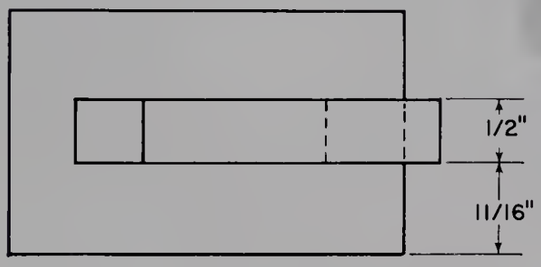
TASK: Write a term paper on the evolution of flexible manufacturing.	
FUNCTION	**ACTIVITY**
Planning	1. 2. etc.
Organizing	1. 2. etc.
Actuating	1. 2. etc.

Fig. 13-A. On a separate sheet of paper, prepare a chart similar to this one on which to record your responses.





RECIPE HOLDER



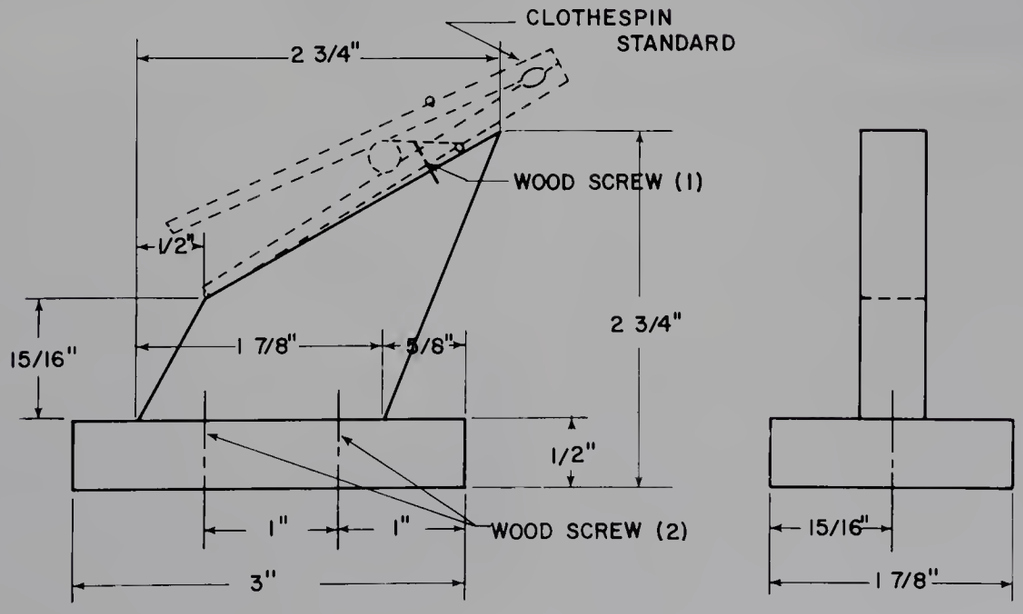


Fig. 13-B. Using this plan, you can produce this recipe holder.



A company manager (center) conducts a staff meeting. (American Association of Blacks in Energy)

14

CHAPTER

COMPANY ORGANIZATION AND STRUCTURE

After studying this chapter, you will be able to:

- *List three considerations that must be present in developing an efficient company structure.*
- *Name and describe the three major forms of ownership.*
- *Describe how participatory management is used.*
- *Identify levels of authority and responsibility in businesses.*

Manufacturing systems use resources to change the form of materials. They add value to raw materials by converting them to more usable forms. People use machines to shape and form materials into products. This activity, as you learned earlier in the text, is called form utility. The new form is more useful than the old form. It has more value (utility) to the customer.

Form utility involves material processing and information processing. These processing activities do not just happen. They are carefully planned and controlled. They require management.

What is management? It is all activities that involve planning, organizing, actuating (directing), and controlling tasks. These managerial actions insure company activities are appropriate and efficient, Fig. 14-1. Management is also a technology. Managers use tools, materials, and systems to complete their work.

All companies must be organized and structured before they can operate efficiently. Developing an efficient company structure requires at least three considerations. They include:

1. The essential elements of the system must be identified.
2. The form of ownership must be established.
3. A managerial structure must be developed.



Fig. 14-1. Management plans, organizes, actuates, and controls company activities to insure that they are efficient and appropriate.

ESSENTIAL ELEMENTS OF MANUFACTURING SYSTEMS

All successful manufacturing enterprises have some common elements. They all use *human resources*, *material resources*, and *capital resources*. These resources are purchased with *money*. People are paid wages and salaries for their time and effort. Suppliers receive money for materials and supplies. Capital (equipment and buildings) is purchased. Management must organize the company to effectively use these resources. Management uses various methods to direct the conversion of resources into products. The products are exchanged for money in the market. This money is called **sales income**. It is

used to pay operating expenses. Any money left after the expenses are paid is profit. Some or all of the profit may be used to expand the company. This money is called **retained earnings** or plowback. It is one source of funds for new product development and manufacturing plants. Profits may also be used to pay the owners a **dividend** or a return on their investment.

The relationship among the keys to successful manufacturing is shown in Fig. 14-2. You will note that money appears twice. It is at the start and the end of the simple cash flow chart. It is the only resource that appears more than once.

This relationship shows that it takes money to make money. A manufacturing company uses money to purchase resources (expenses). The resources are used to make products. The products are sold to customers for money (income). If the income is greater than the expenses, a profit is made.

To be successful, the key elements of manufacturing must be present in proper proportions, Fig. 14-3. For example, a shortage of materials will reduce the number of products that can be sold. Excess materials will demand extra money to maintain inventory. Too few workers will make production difficult. Too many employees will add costs to the products. Too much management adds unnecessary cost to the product. Too little management can result in uncontrolled production activities.

The challenge of management is to operate a company with the least demand for money. This can be accomplished when each element is present in proper proportions.

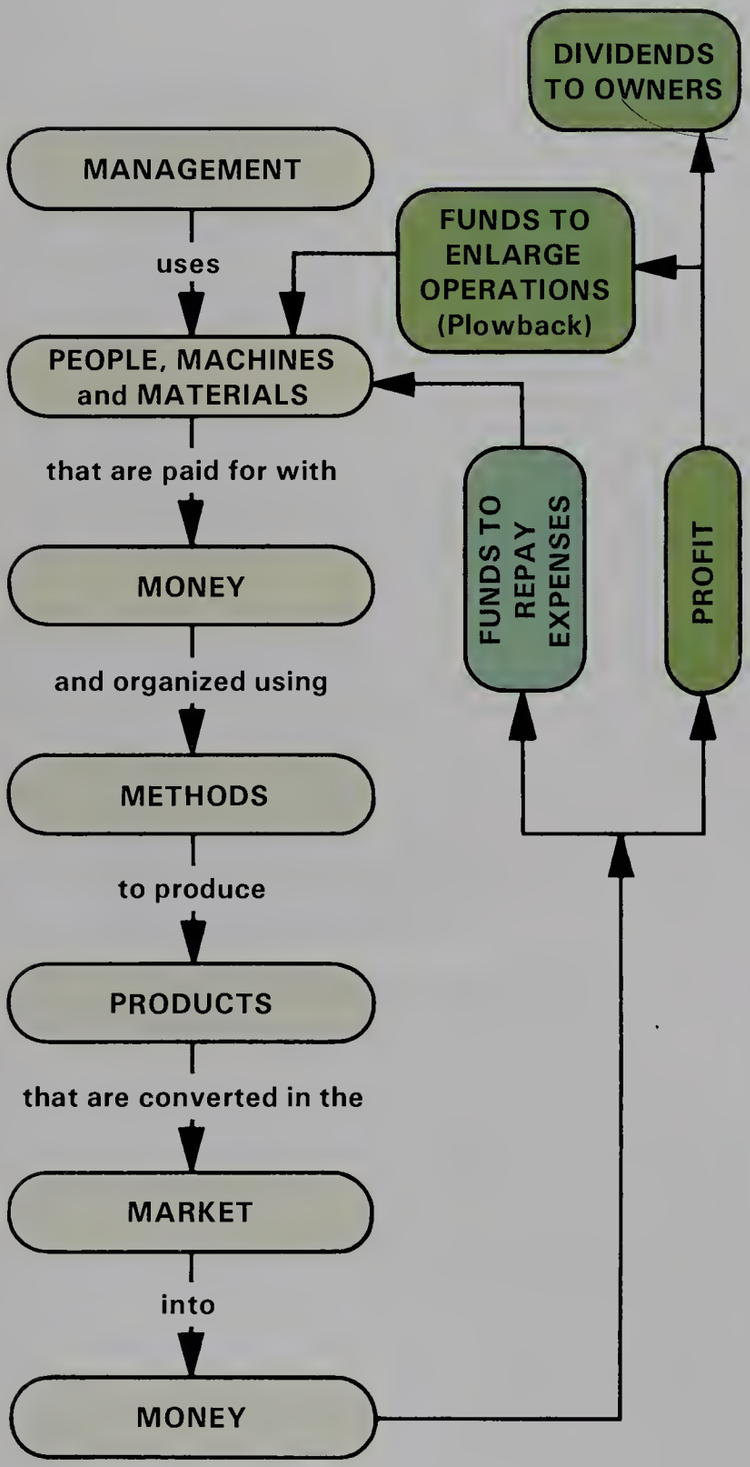


Fig. 14-2. This simple cash flow chart outlines the seven keys to successful manufacturing.

FORMS OF OWNERSHIP

As was discussed in Chapter 13, manufacturing enterprises are developed by entrepreneurs. They

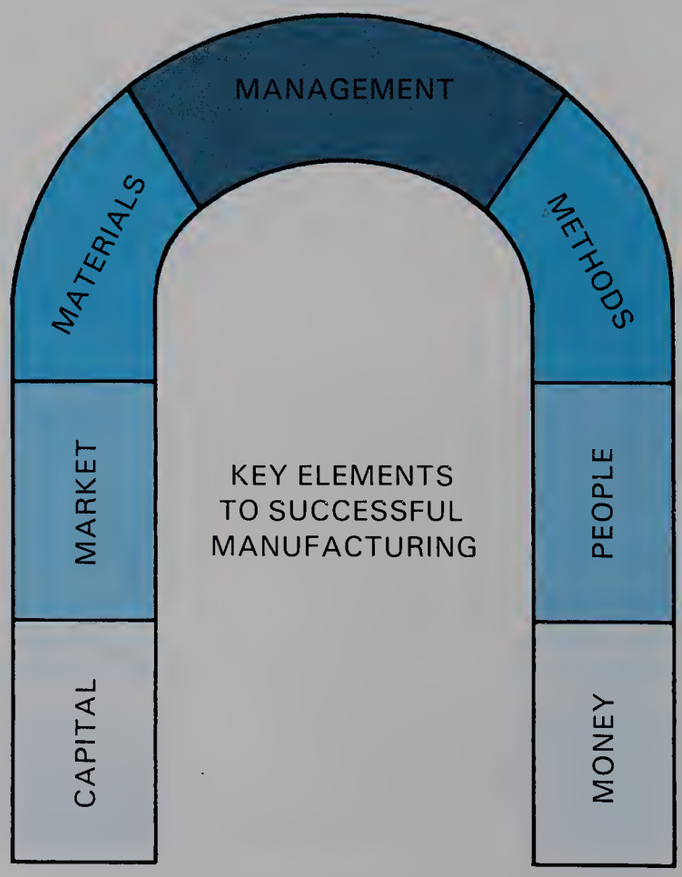


Fig. 14-3. Each key element must be in proper proportion if the company is to be successful.

gather or identify the key elements. They provide the initial ideas and organization. Often, they use their own money to finance early company operations. They are the owners of the enterprise. As owners, entrepreneurs must choose a legal form of ownership for their companies.

They generally select one of three forms of ownership. These, as shown in Fig 14-4, are:

- Single proprietorship.
- Partnership.
- Corporation.

Sometimes, a company will change from one form of ownership to another as it grows. For instance, an individual may start a company. As the demands of the business grow, he or she may acquire partners. More growth may cause the corporate form of ownership to be desirable. In other cases, the company may start as a corporation or remain as a partnership. The form of ownership for each company is selected in terms of its advantages and disadvantages.

SINGLE PROPRIETORSHIP

A **single proprietorship** is a business that is owned by one person. The family farm, a small store, or a service station may be examples of proprietorships. The owner, Fig. 14-5, is the **proprietor**.

Single proprietorships are rare in manufacturing. The cost of machines and facilities make it almost impossible for one person to establish a manufacturing company.

Small companies that make cabinets, custom furniture, and craft items may be proprietorships. See Fig. 14-6. The owners have certain advantages. These might include:

- Easy to form: Single proprietorships are simple to form. In many cases, the owner need only obtain simple licenses from the city or state. Then, he or she can produce and sell a wide range of products.
- Simple control: The owner has complete control of the company's operations. The owner-manager is "the boss" and may easily develop a managerial style that fits the company.



Fig. 14-5. A farmer is often the proprietor of the farm he or she manages. (Deere and Co.)

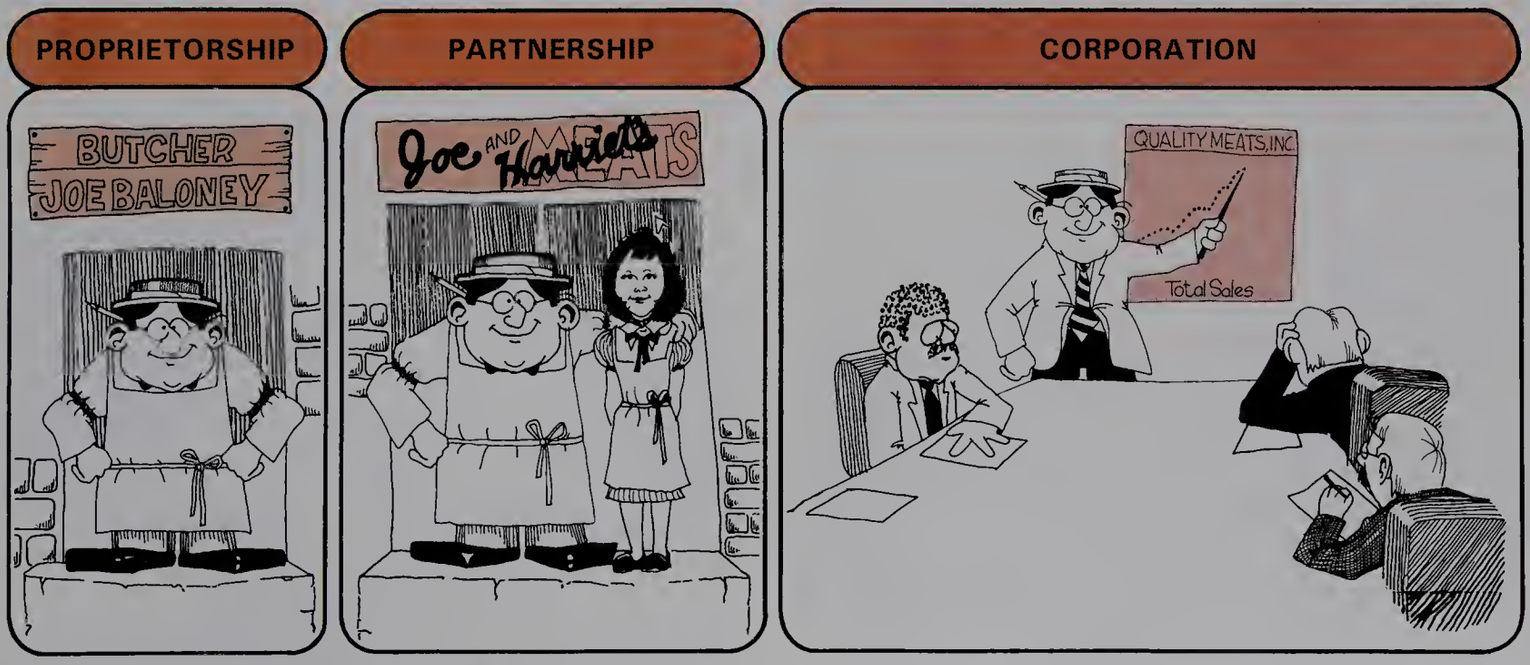


Fig. 14-4. The three forms of private, profit-centered ownership are illustrated above.

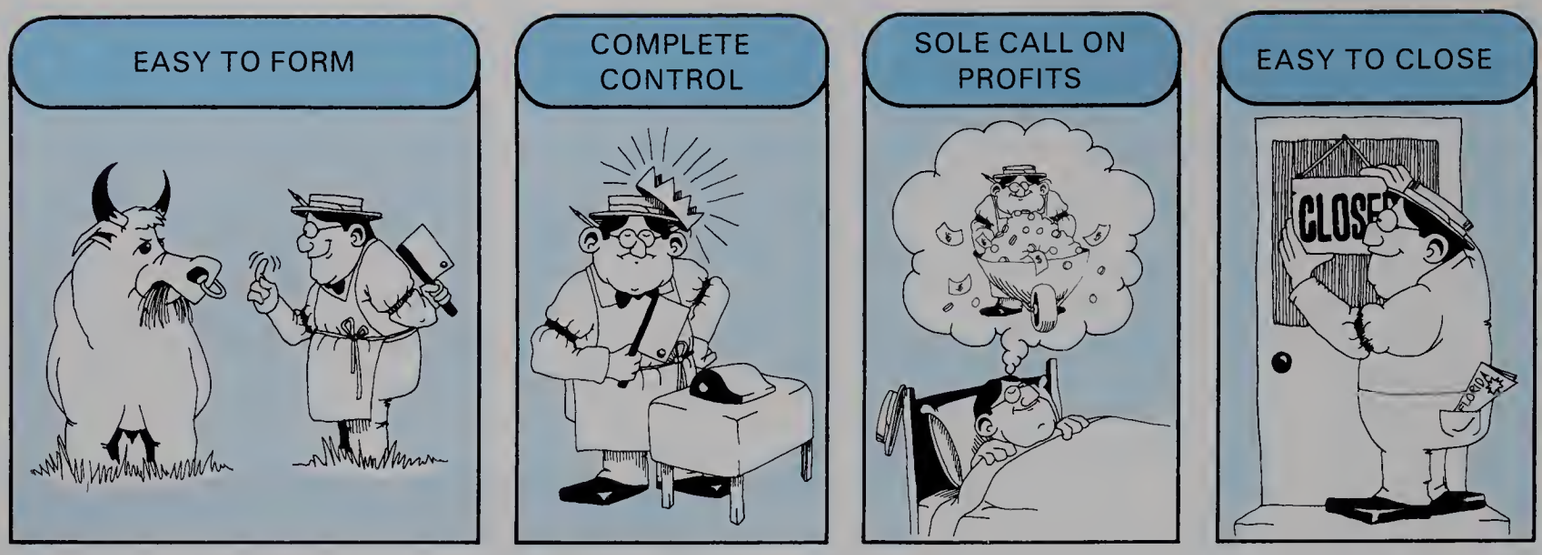


Fig. 14-6. These are some advantages of single or sole proprietorships.

- Sole claim on profits: The proprietor has the sole rights to any profits from the business. He or she is the only investor and has taken the majority of the risk. The income from the company needs to be reported on the person's income tax forms.
- Privacy of records: A single proprietorship is not required to make the company's financial records public. Sales figures, profit statements, and other similar data are private information. Of course, this data is used to prepare income tax forms and file for bank loans.
- Easy to end: A proprietorship is as easy to end as it was to start. The owner may stop business by paying all bills and closing (liquidating) the company.

All decisions in life have advantages and disadvantages. The person deciding to form a proprietorship faces several important obstacles. These include:

- Unlimited liability: The most important disadvantage of a proprietorship relates to business debts. For proprietorships, the law does not separate business debts from personal worth. If a proprietorship fails, the owner is required to use personal wealth to pay the debts, Fig. 14-7. You can see that this liability increases the risk for anyone forming a proprietorship.
- Limited management: Few people have all the skills needed to run a company. An owner/manager must know about production, finances, marketing, and personnel. Often, the original owner (entrepreneur) possesses only some of these skills. The company may, therefore, have areas that are not managed well. Also, the owner may have to spend many long hours managing the company, Fig. 14-8.
- Death of the owner ends the business: The law does not recognize any difference between the owner and the business. Therefore, if the owner dies, so does the business. An heir (husband, wife, son,



Fig. 14-7. A proprietor is responsible for all business debts, even if he or she must pay them from his or her personal funds.



Fig. 14-8. As a proprietorship grows, the owner may have to work long hours to manage the company.

daughter, etc.) may continue the business. However, the business becomes a different company. Another person is the owner and is now responsible for the debts.
- Difficult to finance: The disadvantages noted make the proprietorship economically "unstable." Banks and other financial institutions may hesitate to loan money to a proprietorship. The owner may have to mortgage his or her home, car, or other property to obtain money for the company.

PARTNERSHIP

Another major form of ownership is the partnership. Again, this type of ownership is not common in manufacturing. You will find partnerships in accounting firms, law offices, advertising agencies, and small, family-run businesses.

A **partnership** is two or more persons operating a legal, profit-making enterprise. The partnership is very similar to the proprietorship. It shares several of its advantages including:
- Easy to start.
- Under direct control of the owners.
- Returns all profits to the owners.
- Easy to end.

The normal partnership has equal co-owners and comanagers. This can help overcome some of the disadvantages of the proprietorship. If the partners are carefully selected, they can each bring special management skills to the company. For example, one partner may understand production well. Another partner may be a marketing expert. A third partner may be good with financial records.

It is also easier to finance partnerships. The company can be based on the personal wealth of several people.

The major disadvantage of a partnership is unlimited liability. The owners are still responsible for all company debts. This feature is worse than with a proprietorship. One partner can commit all partners to a debt.

Also, partnerships can have unclear management responsibilities. All the managers are owners and feel they are the boss. Therefore, the employees may have to please several bosses. Workers can be caught in the middle if the owners disagree on the way to do a job.

CORPORATION

Most manufacturing companies are corporations. A **corporation** is a legal "being" formed in one state, Fig. 14-9. In the eyes of the law, the corporation can do many things people can do. For instance, a corporation can:
- Sue people to collect debts.
- Be sued for improper conduct.
- Own and sell property.
- Merge with other companies (marry).
- Divest itself of operations (divorce).
- Start new operations (give birth).
- Cease operations (die).

A corporation is formed by obtaining a charter from one state. Then shares or portions of the ownership are sold, Fig. 14-10. Each share represents a fraction of the ownership. The number of shareholders can vary from a very few to nearly 3,000,000. For example, American Telephone and Telegraph Company (AT&T) has over 2.7 million shareholders and General Motors Corporation has about 1.8 million.

Corporations have several advantages. Four important ones are:
- Limited liability: The owners are not required to pay the debts of the company. Their liability (total amount of money they can loose) is limited to the money they paid for their stock.
- Professional management: The owners generally do not manage the company. People with special managerial skills are employed to direct the day-to-day operations of the company.
- Long life: The corporation is not subject to the lives of its owners. Since the corporation is an artificial "person," individual stockholders (owners) may come and go. They may sell shares or die without serious effect on the company, Fig. 14-11.
- Easy to raise capital: The long life of the company makes it a better risk for financial institutions and individual investors.

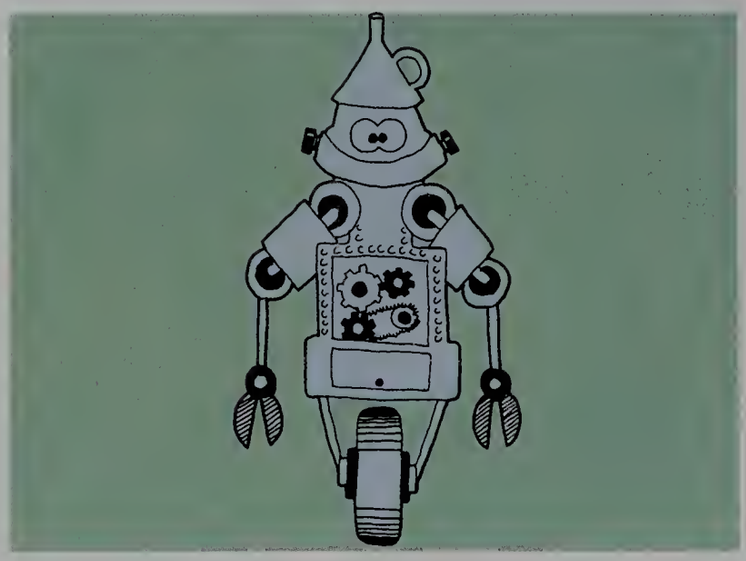


Fig. 14-9. A corporation is a legal being, able to enter into contracts, sue or be sued, and pay taxes.



Fig. 14-10. Owners of a corporation buy shares of the company. (American Telephone and Telegraph Co.)



Fig. 14-11. Every working day, stockholders may sell shares in corporations, often without serious effect upon company operations. (New York Stock Exchange)

These advantages must be weighed against some serious disadvantages. These include:

- High regulation: Corporations are subject to more governmental control and regulation.
- High taxes: The profits of the corporation are subject to local, state, and federal taxes. Then any remaining profits that are distributed to the owners are taxed again.
- Absentee owners: The owners of the corporation generally are not interested in the daily operations of the company. They invest to make money. Therefore, there is often pressure to manage the company for short term profits instead of long term goals.

MANAGEMENT

All companies are managed. Proprietorships and partnerships are usually managed by the owners. Few major corporations employ many of their owners as managers.

Until recently, managers in all forms of ownership were seen as bosses. The workers were expected to carry out the directives of the managers. There was a clear difference between managers and workers.

Most successful corporations are changing this view. They realize that the task of management still exists. However, this task is being carried out in a cooperative manner. Managers and workers are working together to manage company activities. The result is a team. Managers are seen more as coaches who are responsible to the owners. Workers are seen as players that help carry out the vision of the coach. This system is often referred to as the Japanese model. It expects all employees (workers and managers) to participate in managing the company. The result is a type of team management called **participatory management**. See Fig. 14-12.

LEVELS OF AUTHORITY AND RESPONSIBILITY

With any type of management there is a division of labor. People in the organization have specific responsibilities. They also are given authority to complete their work. All this responsibility and authority can be traced to the owners. They, in fact, have all responsibility and authority. In the corporation, they choose to delegate most of their power to other people. They do not have the time or, in many cases, the ability, to manage the company.

A typical flow of authority and responsibility is shown in Fig. 14-13. The owners hold the final or ultimate authority. These people are called **stockholders** in a corporation. They have invested the money to form the company.

The stockholders elect a **board of directors** to represent them. The board is made up of inside and outside members. The inside board members are managers of the company. Outside members are



Fig. 14-12. A manager and a production worker are working to solve a production problem. This is an example of participatory management. (Federal Mogul)

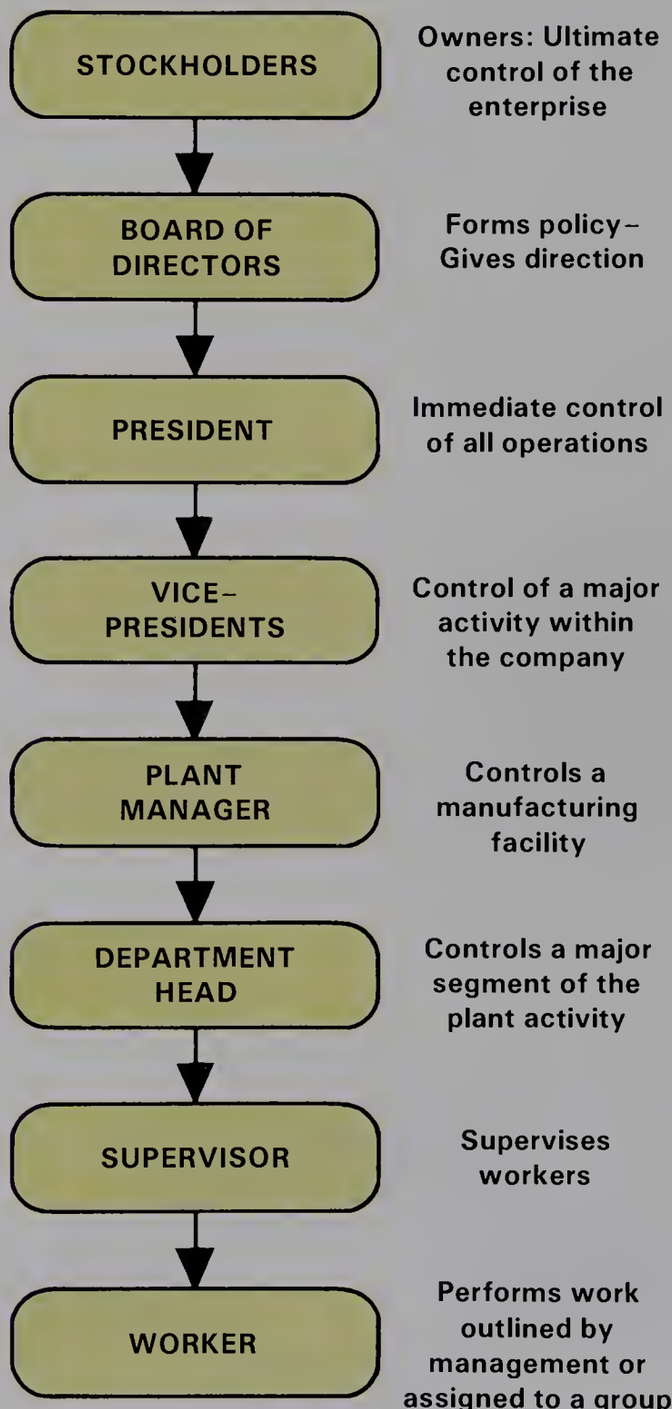


Fig. 14-13. This chart shows the levels of authority and responsibility from the owners to a production worker.

generally employed by some other company or agency. The board of directors develop policies and procedures that give the company general direction. They do not address day-to-day operations.

The board employs key or **top management**. The highest level of management is the president's level. Managers at this level are responsible for all activities of the company. Generally, one to three individuals carry out these duties. Typical titles are *Chairman of the Board*, *Chief Executive Officer (CEO)*, *President*, *Chief Operating Officer*, and *Chief Financial Officer*. In most cases, a person will have two titles, such as Chairman of the Board and Chief Executive Officer or President and Chief Operating Officer.

Several major managers report directly to the president's level. The managers at this level carry several titles, but *vice president* is the most common. The actual title varies from company to company. Vice presidents in manufacturing companies generally manage major portions of the company such as engineering, marketing, and personnel. Large companies have additional layers of management directly below the president's level. Typical titles of these managers are *Executive Vice President* and *Assistant to the President*.

Several levels of management are below each vice president. For example, the production vice president will have *plant managers* that oversee a major production facility. The plant operations will be managed by *department heads* who have *supervisors* reporting to them. Ultimately, the *production worker* completes the manufacturing tasks.

It is important to note that in modern corporations, the term "boss" and "more important positions" are seldom used. All levels of authority and responsibility are important. Production workers, bookkeepers, salespersons, and stockroom clerks are all vital to the running of most companies.

MANAGEMENT STRUCTURES

The flow of authority and responsibility is important. This structure must be understood by all employees. People need to know who answers to them and to whom they must answer. The availability of support staff is also important. Often, companies develop corporate organizational charts to communicate this information. The chart for each company is unique. Probably no two companies are organized in quite the same way.

The simplest organizational system is called **line organization**, Fig. 14-14. In this system, every position reports to only one manager above it. Information and directives flow up and down the structure in straight lines. This structure is sometimes called the *military model*.

More complex organizations include a number of staff functions. **Staff employees** give advice to the operating managers. For example, the human resource development (HRD) staff will advise supervisors on personnel matters (union contract interpretation, hiring, etc.). The line and staff organization is fairly common for manufacturing corporations, Fig. 14-15.

Other companies use modifications of these systems. Committees may be used to complete some tasks. Project teams may be used to complete specific activities, such as designing a new product.

SUMMARY

Manufacturing companies are legal structures that operate to produce products. They use people to

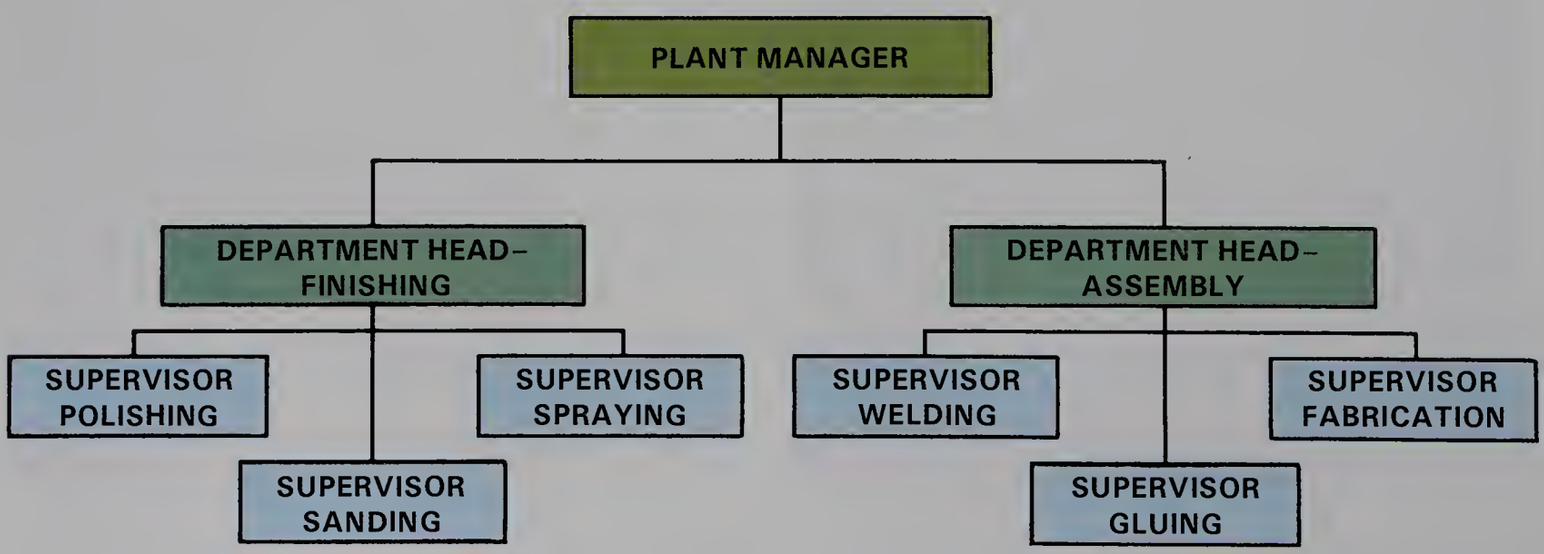


Fig. 14-14. This is a simple line organization chart.

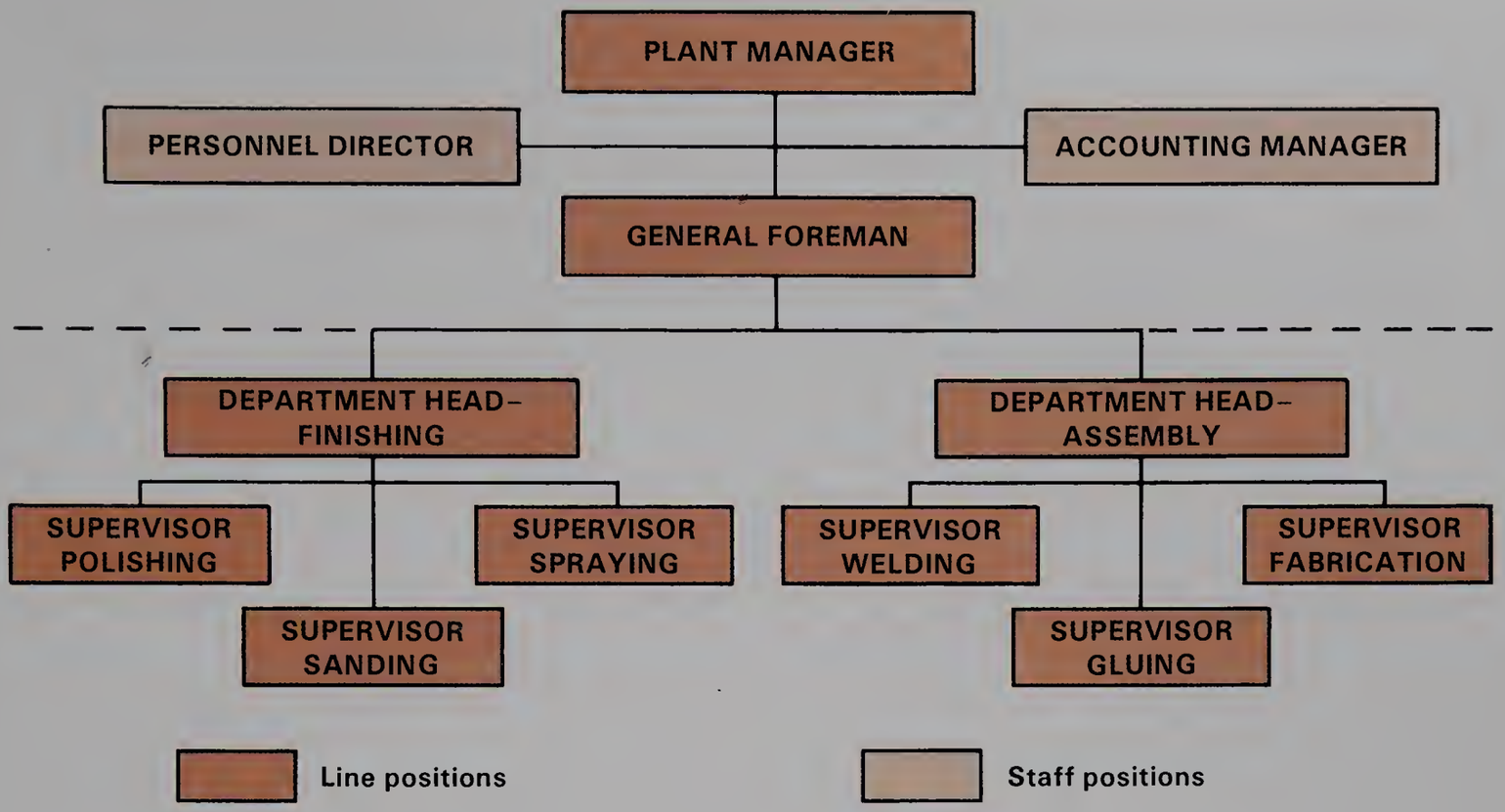


Fig. 14-15. A sample line and staff organization chart is shown above.

operate machines that change materials into goods. These resources are purchased with money. The three basic inputs are made to work efficiently through methods that are developed by management. The products are sold in the marketplace to generate money. The money from sales can be used to pay expenses, expand the company, and to reward stockholders for their investments.

Companies may be proprietorships run by an owner/manager, or by a partnership of two or more people. The most common organization for manufacturing enterprises is the corporation.

Each company is organized into levels of authority and responsibility. This structure is often shown through a corporate organizational chart.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

board of directors
corporation
dividend
line organization
participatory management
partnership
proprietor
retained earnings
sales income
single proprietorship
staff employees
stockholders
top management

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List three considerations that must be present in developing an efficient company structure.
2. Explain why it takes money to make money.
3. List and describe the three major forms of business ownership.
4. True or False? In a proprietorship, the death of the owner ends the business.
5. True or False? In a partnership, one partner cannot commit all the partners to a debt.
6. In a _____, each share represents a fraction of the ownership.
7. _____ management is a type of team management where all employees (workers and managers) participate in managing the company.
8. Which of the following would hold the final or ultimate authority in a corporation?
   a. Stockholders.
   b. Chairman of the board.
   c. Chief executive officer (CEO).
   d. Plant managers.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Continue to either line or custom produce the product started in Chapter 13.
2. Assume you plan to start a company to make pennants for all the schools in your region. Select a type of ownership you would use and develop an organizational chart of the company, including all five major areas of activity (research and development, production, marketing, industrial relations, and financial affairs).
   a. Study the forms of ownership in Fig. 14-1. Decide which is likely to be most suitable for your company.
   b. Decide what kind of management structure you will have. Refer again to the section on "Management Structures" in this text.
   c. Develop an organizational chart for your company. (Refer to the chart in Fig. 14-14.) List the various positions or titles of jobs on your chart.

15

CHAPTER

MANAGED PRODUCT-CENTERED AREAS

After studying this chapter, you will be able to:

- *List three product-centered activities used in manufacturing.*
- *Explain the functions of research and development in manufacturing systems.*
- *Name and discuss the four functional areas of production.*
- *Describe the role marketing plays in manufacturing systems.*

Product-centered activities directly move a product idea from the designer's mind to the market. In Chapter 13, you were briefly introduced to the managed areas of activity in manufacturing. These areas included research and development, production, marketing, financial affairs, and industrial relations. The first three are product-centered activities, Fig. 15-1. Each of these three product-centered activities will be explored separately in this chapter.

RESEARCH AND DEVELOPMENT

Have you ever wondered where new product ideas originate? Who is responsible for the thousands of items that appear on store shelves? How do machine operators know what size to make parts? How do assemblers know how to put parts together to form products? How do managers and workers determine the quality standards for each part and product? These and many other questions are answered through research and development activities in a manufacturing enterprise.

Research and development determines, to a large extent, the future of a manufacturing enterprise. Workers and managers in this area develop new and improved products and manufacturing processes. Without a research and development effort, a company must depend on other companies for product ideas. It is forced to be a follower rather than a leader.

Many manufacturing companies provide modern facilities for their research and development activities, Fig. 15-2. Inside these facilities, scientists,

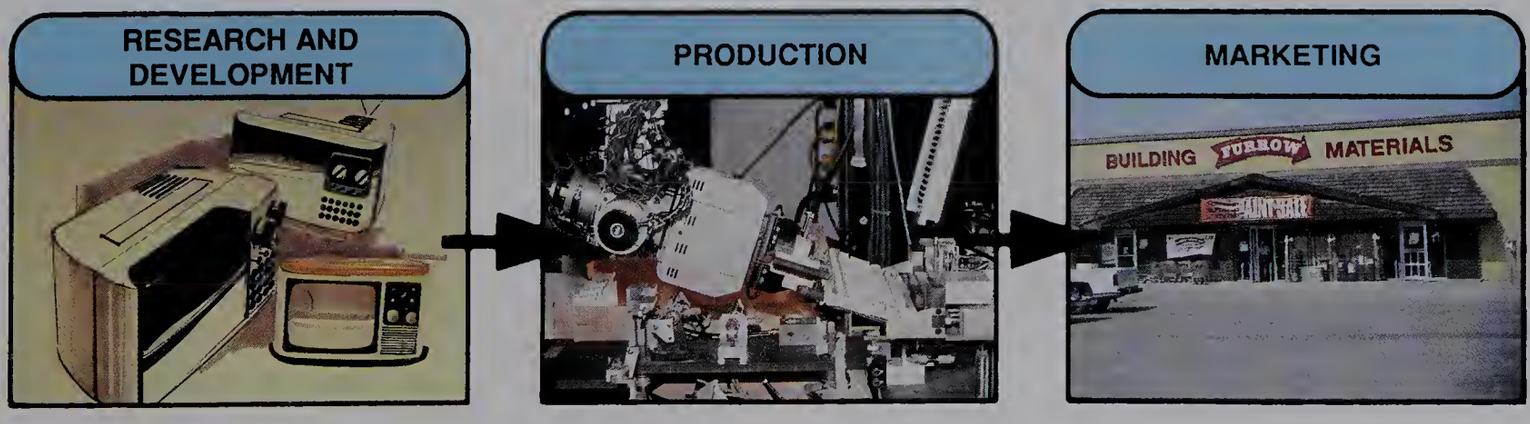


Fig. 15-1. Research and development, production, and marketing activities move a product from the designer's mind into stores. (RCA, IBM)



Fig. 15-2. This modern research facility provides a home for many new product and process development activities. (Armstrong Cork. Co.)

engineers, and technicians complete many tasks. These can be grouped under three major functions that help move a designer's ideas from his or her mind into reality. See Fig. 15-3. These functions are:

- Research.
- Development.
- Product engineering.

RESEARCH

Research is an important phase of the research and development activity. It is the systematic (step-by-step) search for unknown facts or principles. Through research activities, new knowledge is discovered and developed. It is the fountain from which new and improved product and process ideas flow.

However, research is not an isolated activity. It is often the result of teamwork. For example, research and marketing people work together to identify product needs. Researchers and production personnel seek better ways to make products.

Research activities are generally grouped into two major activities. These, as shown in Fig. 15-4, are:

- Basic research: Seeking new knowledge for its own sake.
- Applied research: Seeking knowledge to solve specific problems or to meet a commercial goal.

Basic research

Basic research projects contribute knowledge to our general understanding of the universe. They are

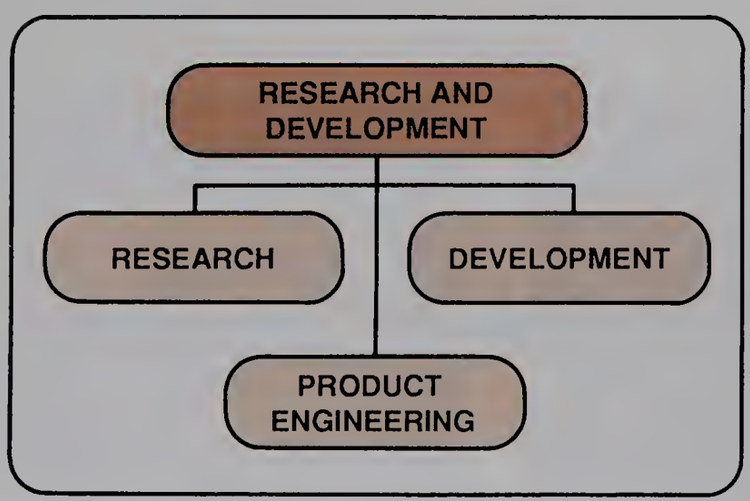


Fig. 15-3. These are the managed functions of the research and development activity area.

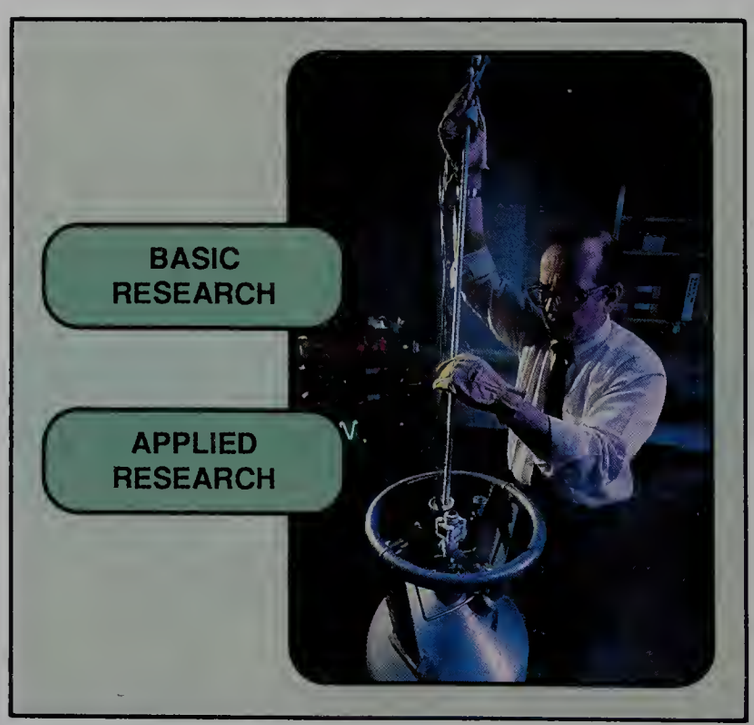


Fig. 15-4. Research activities can be categorized as basic or applied research. (E.I. DuPont deNemours and Co.)

not expected to end with a specific product or process. Instead, they add information to the "library of knowledge" that may someday be used to solve specific problems.

Private industry funds only a small portion of the basic research undertaken. Instead, the government underwrites most of the expense. The results are then available to many different enterprises.

The space program has been involved in many basic research projects. We have learned a great deal about the universe in which our earth is located. Space probes, Fig. 15-5, gather many types of information that can later be used to develop communication systems, address the greenhouse effect, study the ozone layer, and many other specific issues.

Applied research

Applied research activities are designed to gain specific knowledge. Projects solve a problem or meet a practical purpose. Projects may be directed toward a new product, or they may solve problems with products currently on the market. Projects may also seek ways to improve manufacturing processes.

Applied research projects may be further divided into specific types. These include:

- *Product research:* Research is directed toward developing new or improved products.
- *Manufacturing research:* Research is directed toward developing new or improved manufacturing processes.
- *Operations research:* Research is directed toward developing or improving the ways the company manages its various activities.
- *Materials research:* Research is directed toward developing and improving the materials used to manufacture products.

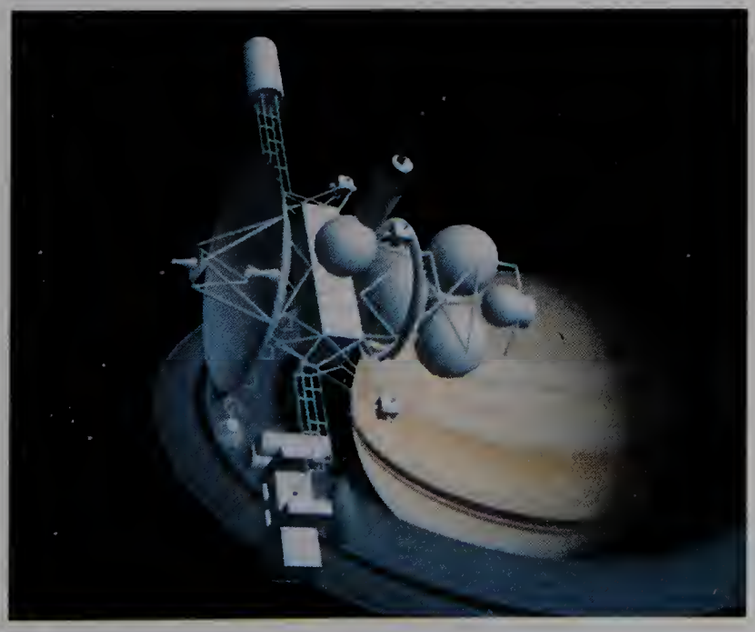


Fig. 15-5. This proposed spacecraft will study Saturn and its moon, Titan. (NASA)

DEVELOPMENT

Knowledge is good, but is doesn't meet our physical needs. It becomes useful only when it is applied to a product or process. This is the task of **development**. This area takes the knowledge gathered through applied research and carries it one step further. It finds a use for the knowledge discovered.

Development activities move ideas from laboratory notes and mental pictures into actual models. Developmental engineers and technicians change information into marketable products or workable processes. Their work, as shown in Fig. 15-6, may be of two major types:

- *Product development:* Knowledge is applied to create new or improved products.
- *Process development:* Knowledge is applied to create new or improved manufacturing processes.

Product development

Product development involves making several designs for new or improved products. Product developers construct and test prototypes of these designs. These tasks generally start with the general requirements for a product.

The general specifications are used as a guide in developing a number of possible solutions. Designers

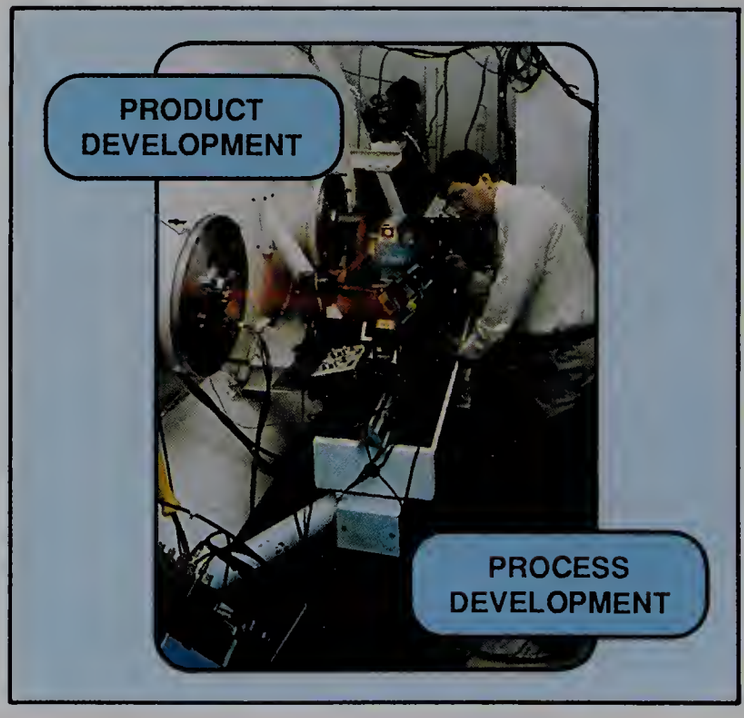


Fig. 15-6. Companies engage in product and process development. (Arvin Industries)



Fig. 15-7. This designer is developing a rendering (a colored sketch) of a possible new product. (Ohio Art Co.)

sketch and refine many different ideas. Then they select the ones that have the most promise, Fig. 15-7. These ideas are changed into models.

Models may simply show how the product will look. These appearance models are called **mock-ups**, Fig. 15-8. They help answer the question, "Will people like the appearance of the product?"

Working models or **prototypes** are also developed. They are used to test the actual operation of the product. The prototype helps answer the question, "Will the product work as the customer expects?"

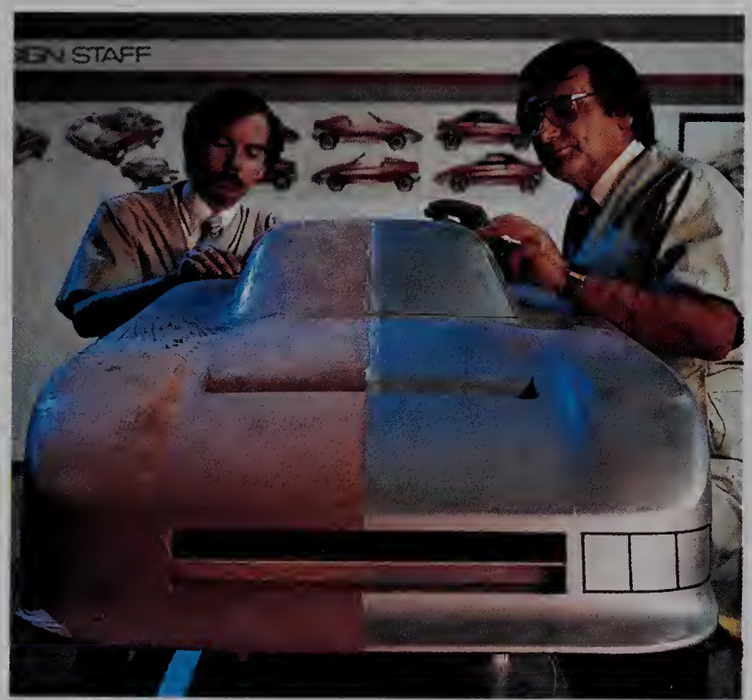


Fig. 15-8. Mock-ups, like this clay model of an automobile, show how a product will look. (Motor Vehicle Manufacturers Assoc.)

The product development activities may follow one of three major types of *design approaches*. These, as shown in Fig. 15-9, are:

- *Imitation:* A new product is designed to be like another product that is on the market. It is intended for an identical market. Examples might include another brand of orange soda, laundry powder, or toothpaste.
- *Adaptation:* A new product is a modification (improved version) of an existing product. It is designed to replace the older product. The product is intended for an established market. Examples might include a ten-speed bicycle versus a standard bike; an electronic typewriter versus a manual typewriter.
- *Innovation:* A truly new product is designed with new technology and characteristics. It is not necessarily intended for an established market. Examples include fiber optic communication systems, microchips, or personal computers.

Process development

Development puts scientific discoveries into practice. Some of these discoveries relate to machines, tooling, plant layout, and material handling. Process development must integrate these discoveries into existing or new production facilities, Fig. 15-10. Process development is closely related to manufacturing engineering that will be discussed later in this chapter. Process development applies new knowledge to manufacturing processes. Manufacturing engineers develop efficient facilities using existing knowledge. They apply the various processes that have been developed by process developers.

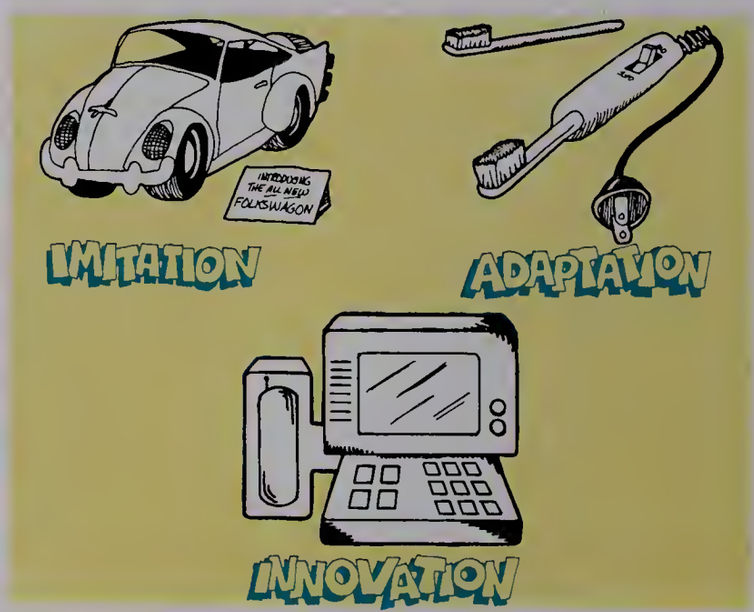


Fig. 15-9. Product development may imitate, adapt, or innovate.

PRODUCT ENGINEERING

The third function of research and development is called **product engineering**, Fig. 15-11. The role of product engineering is to specify the characteristics of the product. Project engineers also test the performance of a product and provide consulting services to the production area of the company.

Product design

Product engineers focus most of their attention on *product design*. The term, product design, may be somewhat confusing. Product engineers are not the only people who deal with product design. Original designs are developed by workers in product development. Product engineers refine these designs for manufacture. They make sure that the product can be built.

Product engineers must communicate the final designs to production personnel. They use three basic methods for specifying the characteristics of the product:

- Engineering drawings.
- Specification sheets.
- Bills of materials.

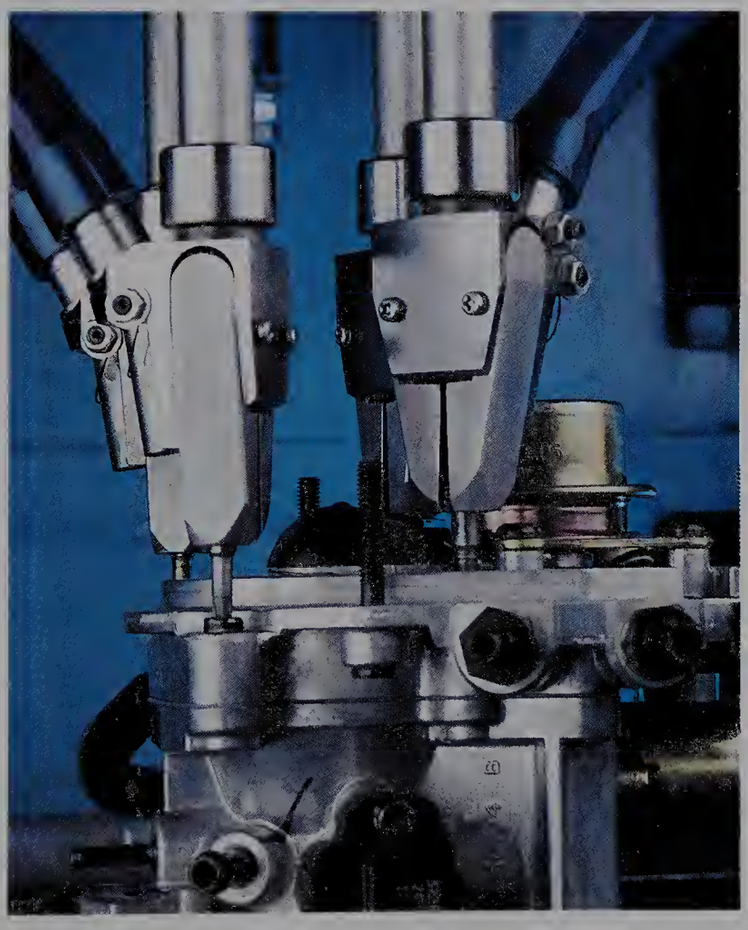


Fig. 15-10. This automated assembling device was developed through process development activities. (Colt Industries, Inc.)

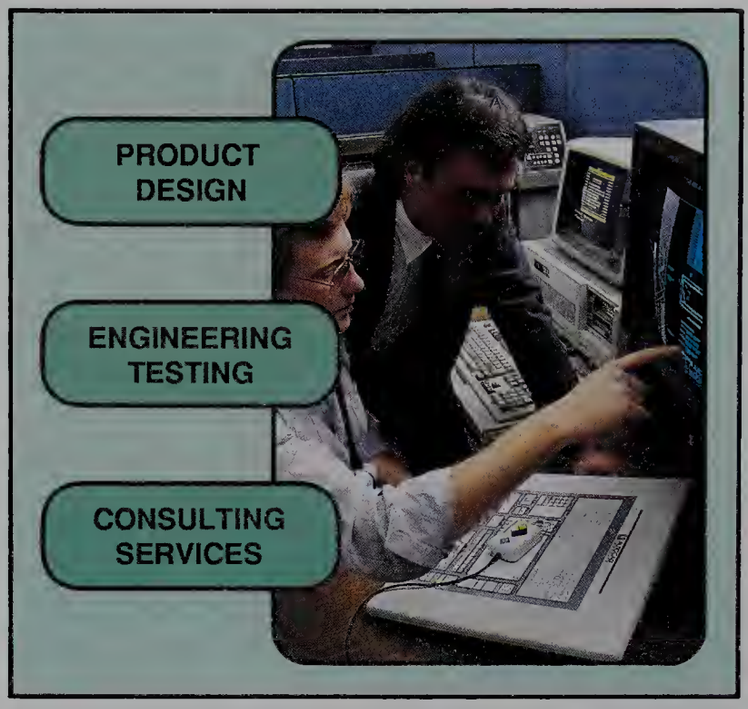


Fig. 15-11. These are product engineering tasks. (Hon Industries)

Production personnel must know the size and shape of the parts to be manufactured. They must also know how various parts fit together to make products. This information is contained on working drawings.

Three types of drawings are used. These drawings include detail, systems, and assembly drawings.

Detail drawings provide production information for a single part, Fig. 15-12. They communicate size, shape, and surface finish information. Most detail drawings are multiview or orthographic drawings.

Systems drawings (schematics) are used to show the layout of various systems, Fig. 15-13. These may

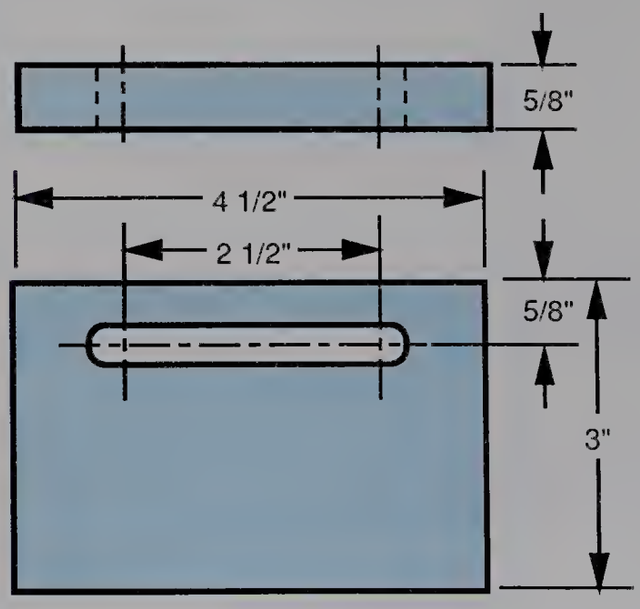


Fig. 15-12. A typical detail drawing is shown here.

be electrical, pneumatic, hydraulic, or mechanical systems. These drawings show the relationship between components in the systems. The actual location of the component is not communicated on system drawings.

Assembly drawings show assemblers how parts go together, Fig. 15-14. Assembly drawings are also widely used in service manuals. They show part numbers and the proper way to disassemble and assemble the product.

Not all information needed to make a product can be shown on a drawing. Some items are selected for factors other than size and shape. For example, can a useful drawing of sheet steel, or lubricating oil, or woodworking adhesives be made?

For industrial materials, designers and engineers are interested in characteristics that cannot be shown on drawings. They are concerned about strength, weight, chemical resistance, color, texture, and many other properties. These characteristics must be described with words. They are summarized on **specification sheets.**

A third way to communicate product characteristics is with a bill of materials. This form lists all the parts or materials needed to construct a product. This information is used to purchase materials, schedule machines, and establish product costs. A typical bill of materials lists the part number, quantity needed, size, and material needed for each part.

ENGINEERING TESTING

A second task of product engineering is **engineering testing.** During this phase, a product is carefully checked for quality and function, Fig. 15-15. The product is subjected to the same conditions it will

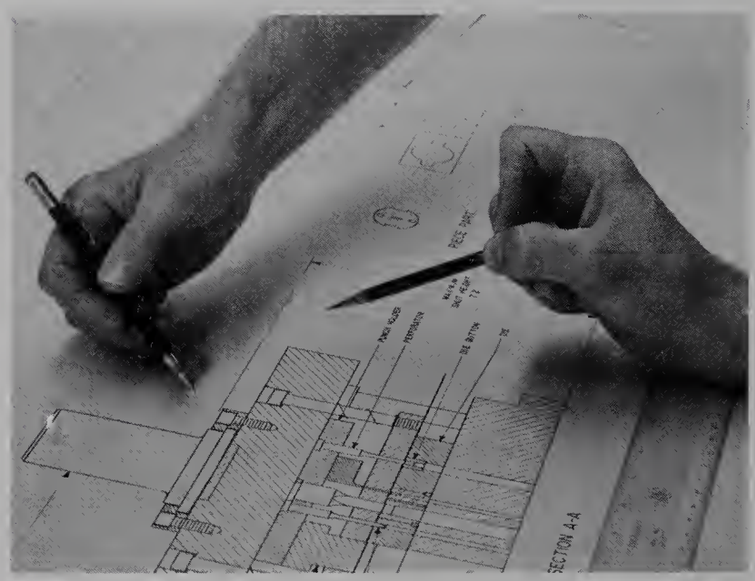


Fig. 15-14. An assembly drawing for a punch press die is being reviewed. (Western Electric Co.)

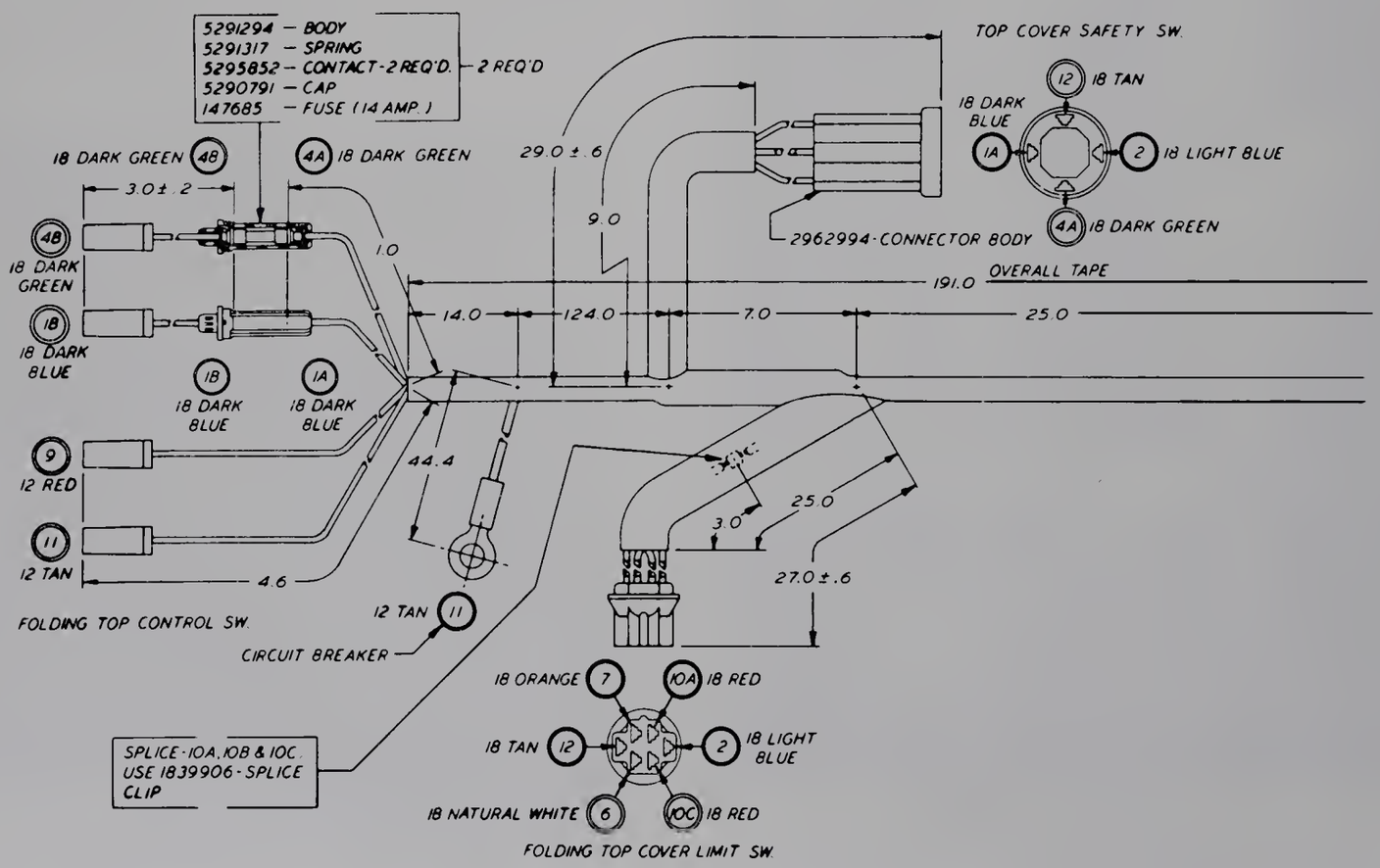


Fig. 15-13. This is an automotive electrical schematic drawing. (General Motors Corp.)

experience in the field. The results indicate the reliability, safety, and operation of the product. The data is used to prepare owner's and service manuals. It also indicates areas for product redevelopment.

CONSULTING SERVICE

The emphasis in modern manufacturing is design for manufacture. Products are developed so that high-quality (world-class) products can be built with ease. The number of parts and operations are reduced to the minimum.

Product engineers provide information and help production officers meet the world-class product challenge. They consult on product design and process changes. Where possible, product engineers will change designs to facilitate the manufacture of the product.

PRODUCTION

Look around you. How many products do you see? All are the output of manufacturing enterprises.



Fig. 15-15. This hammer is being tested in an engineering testing laboratory. (The Stanley Works)

The managed area responsible for making products is called production. It sees that inputs are efficiently converted into desired outputs, Fig. 15-16.

The work of production personnel may be grouped under four functional areas. These, as shown in Fig. 15-17, are:

- Manufacturing.
- Manufacturing engineering.
- Production planning and control.
- Quality control.

Production is a critical aspect of manufacturing. All profits of the company can be traced to its ability to create value in materials. Production uses labor in operating machines to change the form of various materials, Fig. 15-18. The result is the added value or form utility.

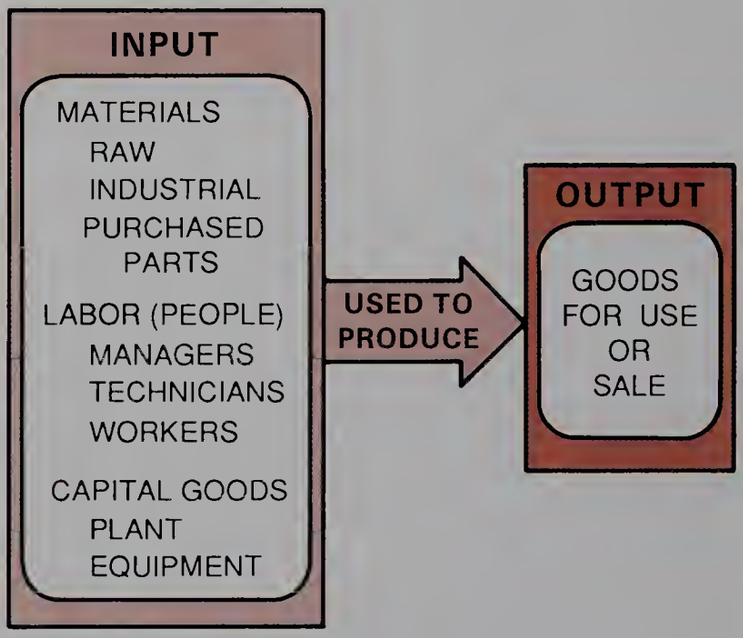


Fig. 15-16. The production area manages the conversion of resources into products.

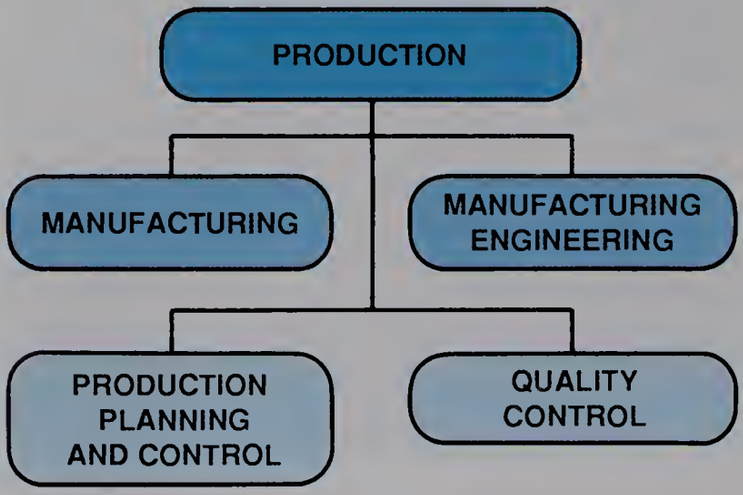


Fig. 15-17. These are the managed functions of the production activity area.

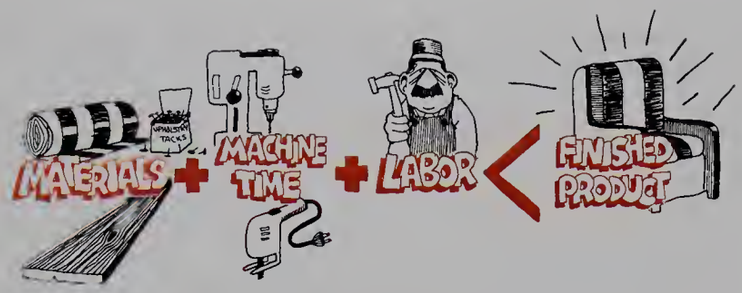


Fig. 15-18. Manufacturing uses labor and machines to add value to materials.

MANUFACTURING

Personnel in the manufacturing function make the product. They change the shape and size, composition, or combination of materials or parts. Manufacturing activities may be carried on in one of four types of systems: custom, continuous, intermittent, and flexible. The type of system used will dictate many actions carried out by production personnel. Therefore, let's look at each system briefly.

Custom manufacturing

Custom manufacturing is the oldest production system, Fig. 15-19. It is used to produce a small number of products to a customer's order. Highly skilled workers use general purpose machines to individually produce each part. The parts are carefully fitted into the final product. Today, custom manufacturing techniques are used to produce products like spacecraft, special purpose machines, and stamping dies for other industrial processes.



Fig. 15-19. Custom manufacturing uses skilled workers to produce limited quantities of products to meet customer orders. (RCA)

Continuous manufacturing

The opposite of custom manufacturing is **continuous manufacturing**. It uses special-purpose machines to produce large quantities of like products. The system is developed to produce products with limited variations.

Continuous manufacturing is based on uniform parts or materials that flow from station to station. The total manufacturing task is divided into discrete elements. Each task is assigned to a workstation. This station is generally operated by a semiskilled (trained for a single job) worker.

In many cases, the work is being transferred to automatic machines and robots, Fig. 15-20. Continuous systems are widely used in producing basic materials like plywood, lumber, and paper. Also, many products such as automobiles, household appliances, and furniture are manufactured continuously.

Intermittent manufacturing

Intermittent manufacturing is used when continuous production is not practical. It involves producing parts or products in lots. For example, 2000 shafts for a small gasoline engine may be needed. The quantity is too small for continuous systems. Instead, 2000 steel blanks may be cut. They would then be



Fig. 15-20. The machine at right is part of a continuous manufacturing control system. (E.I. Dupont deNemours and Co.)

moved together (in a lot) through the manufacturing stages. At each work station, all 2000 parts would be processed before they moved to the next station. Intermittent manufacturing is often called *job-lot manufacturing*.

Flexible manufacturing

The development of computer-controlled machines has resulted in a new type of manufacturing system. This system is called **flexible manufacturing**, Fig. 15-21. It will be discussed in more depth in Section 6 of this book. Flexible manufacturing uses the special machines and tooling of continuous systems. However, the computer allows the production run to be small. Setup time is reduced, and quality control is increased with the use of the computer. Lots as small as one product can be built with the cost advantages of continuous manufacturing.

MANUFACTURING ENGINEERING

A production facility must be engineered before product manufacture can begin. The proper operations must be selected and sequenced. Equipment must be placed in a logical order. Tooling must be built. Methods of moving materials through the plant must be developed. All these jobs are the responsibility of **manufacturing engineering**. This work involves five major tasks:

- Methods study: This involves developing efficient work methods by selecting and sequencing operations and developing efficient work stations. Existing or proposed methods of producing the product are analyzed. Emphasis is on eliminating unnecessary worker motion and reducing machine time.
- Plant layout: This involves assigning space within the plant to various activities and arranging the equipment to promote efficient operations. Specific emphasis is placed on the efficient flow of people and materials in the plant.
- Material handling: This involves developing and installing efficient devices to move materials from station to station in the factory. Emphasis is placed on eliminating unnecessary movement of materials. All material movement adds costs to the product and risks material damage.
- Tooling: This involves designing and fabricating special cutters and holding devices that will increase the speed, accuracy, and safety of operation, Fig. 15-22. Emphasis is placed on removing as much work from the worker as possible and placing it in the machine. Tooling activities produce:
  a. Tools: These are specially shaped cutting and forming devices, such as punches, dies, and cutters.
  b. Jigs and fixtures: These are machine attachments that hold and locate the part. Fixtures

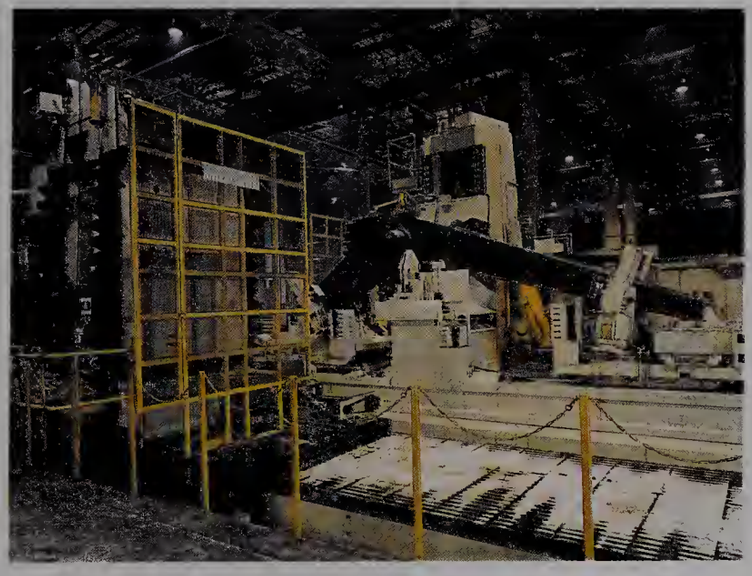


Fig. 15-21. This flexible machining cell can be quickly reprogrammed to produce a number of different parts. (Caterpillar, Inc.)



Fig. 15-22. This assembly tooling improves the speed and accuracy of aircraft assembly activities. (Eaton Corp.)

only hold the workpiece. Jigs hold the work and guide the cutting tool.

c. Patterns and templates: These devices are the same shape as the part. Templates are two-dimensional outlines of the part, such as cutting templates. Patterns are three-dimensional representations for the part, such as foundry patterns.

- Time study: This involves establishing estimated times required to complete each major task in making a product. These times are used to estimate production cost, schedule people and machines, and to divide the total job into parts that can be completed at work stations.

PRODUCTION PLANNING AND CONTROL

Another activity that must be completed before manufacturing is **production planning and control**. This function must plan for and schedule the manufacturing activities. Production planning and control is concerned with:

- Establishing the number of products to be built.
- Determining when and where to build products.
- Maintaining the production schedules.

Production planning and control develops production orders, releases them, and follows up on their completion. This work can be divided into four major tasks, as shown in Fig. 15-23. These are routing, scheduling, dispatching, and expediting.

Routing determines the best path for the parts and products. It determines where each operation of a part will be performed. It then establishes the route the material will travel from raw material to finished product. Continuous manufacturing systems have the routes built directly into the system. The product moves along the manufacturing line. Intermittent and custom manufacturing require that each product have its own path.

Scheduling determines when the product will be built. It decides when each operation will be completed. Scheduling assigns workers and machines to the task. Continuous manufacturing systems operate at a set number of products per hour. Therefore, scheduling production is fairly easy. Products are simply assigned to the line. Intermittent systems must have each worker and machine scheduled.

Dispatching involves issuing production orders to start the manufacturing process. Dispatching involves releasing purchase orders, fabrication (part manufacture) orders, and assembly orders. Additionally, in intermittent manufacturing, orders for inspection and material movement are required.

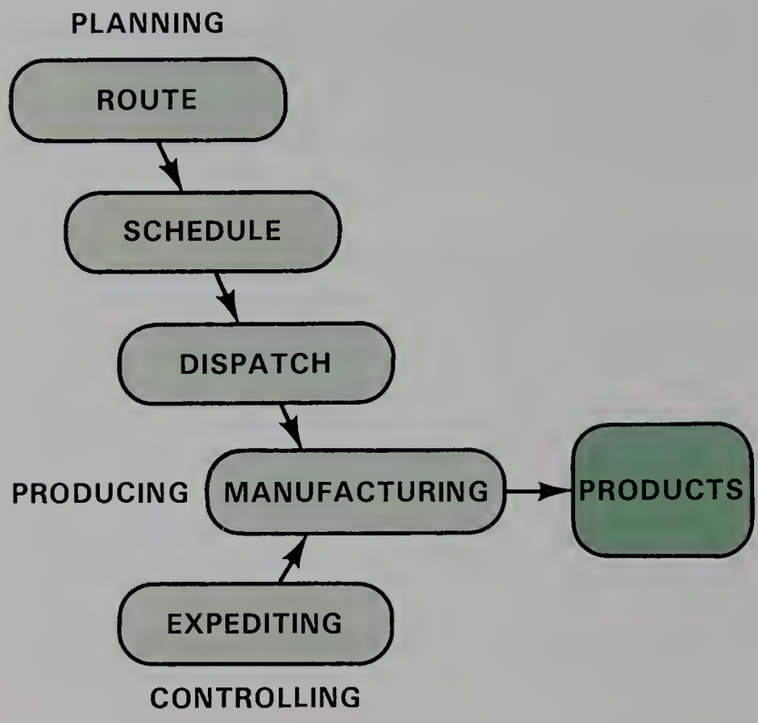


Fig. 15-23. Production planning and control tasks are outlined above.

Expediting is the control function of production planning and control. It checks to see that production is meeting schedules. It determines if:

- Materials are arriving on time.
- Parts are being produced according to schedule.
- Assembly is completed on schedule.

Follow-up activities are used when the schedules are not met. They will speed up material procurement, part manufacture, or assembly operations. The constant goal of expediting is to produce products according to established schedules.

QUALITY CONTROL

Quality control involves all the activities designed to cause a product to meet stated standards. Quality is the degree of fineness built into the product. Quality standards are set by product engineering. They should match the intended use of the product. Quality does not mean smooth, bright, or colorful. For example, smooth nails function poorly. They will not hold in wood as well as rough nails. Within a box of nails, there are varying degrees of quality. However, the most important features for a nail are a head on one end and a point on the other. The head and body diameter need to be approximately, not exactly, the same.

A quality control program has two major parts. These are:

- A quality control plan to insure that all employees recognize the importance of quality.

- An inspection system to identify and remove products that do not meet quality standards.

Quality control program

Quality products are produced by people who believe quality is important. For many years, management developed programs to tell people that quality was important. These programs were advertising-type programs. They had posters, badges, and slogans. The programs encouraged workers to "think quality" and to work with "zero defects." Some of these programs worked well, but others did not.

A new quality control approach is being adopted by some industries. This program was developed in the United States but received little interest. However, it was successfully used in Japan. Recently, it has received renewed interest in the United States and Canada. It is called **quality circles**. This is one phase of participatory management. The workers and managers form quality control teams or circles. They meet periodically to discuss ways of improving quality. They suggest specific actions that will reduce scrap, speed operations, and improve quality. Refer to Fig. 15-24.

Inspection

All workers make mistakes. Machines can lose their adjustments. Tools can break or become dull. Any of these situations can produce a product that fails to meet quality standards. **Inspection** must locate and remove these products from the manufacturing system, Fig. 15-25. Inspection involves:

- Determining quality standards from engineering drawings and other specifications.
- Inspecting incoming materials and purchased parts to insure they meet quality standards.
- Inspecting products at various stages during manufacturing to see that they meet quality standards.
- Inspecting finished products to insure that they meet quality standards.
- Recommending corrective action to reduce scrap and rejected products.

The frequency of each of these inspections will vary with the product. Inspections add cost to the product. Therefore, it is unwise to inspect every inexpensive product. Total inspection of screws, washers, or nails would be too costly. However, expensive products or products that could have life-threatening defects, require careful and complete inspection. For instance, the steering mechanisms of all cars should be carefully and completely inspected.

MARKETING

Designing and producing products is only part of manufacturing. The completed products must move from the manufacturer to the customer. Encouraging this flow of goods is called marketing, Fig. 15-26.



Fig. 15-24. These workers, participating in a quality circle meeting, are looking for ways to improve product quality.



Fig. 15-25. This automotive assembly is being electronically gauged for quality. (The Budd Co.)



Fig. 15-26. Marketing is the bridge from the producer (manufacturer) and the consumer (customer).

The market is the place where products change ownership. It is the combined action of sellers and buyers. The level of this action will directly impact a company. If there are more buyers than sellers, product demand will be high. This situation generally leads to higher prices. It also encourages competition. Other companies tend to enter markets where customer demand and profits are high.

If there are more products than sales, the market will be weak. Prices and profits will drop. The least efficient companies will lose money on the product. They will be forced to leave the market.

Most products you buy represent the end of a series of complex marketing activities. Marketing personnel follow these steps:

1. Determine who the potential market (customers) are for a product.
2. Develop an awareness of and interest in the product.
3. Design a system to sell the product.
4. Distribute the product.
5. Exchange the new product for money (sell the product).
6. Provide service for the product.

These and other marketing tasks may be grouped under four major functions, as shown in Fig. 15-27. They are market research, advertising, sales, and distribution.

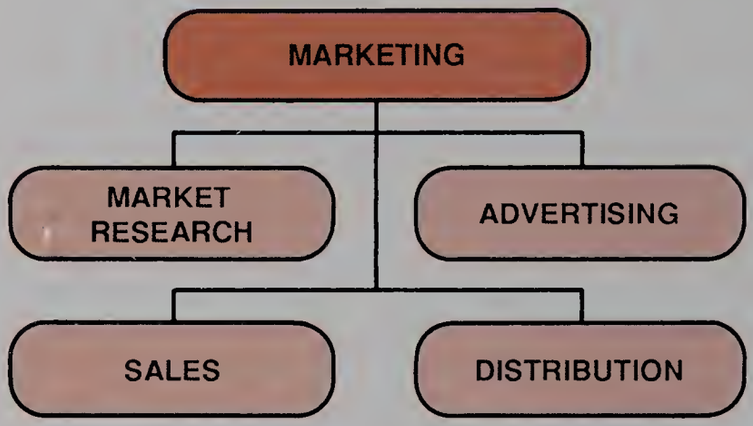


Fig. 15-27. These are the functions of the marketing area.



Fig. 15-28. Market research gathers information about the product, market, and marketing system.

MARKET RESEARCH

Products are built to meet human needs and wants. Information about the market must be gathered before wise product development decisions can be made. This activity is called **market research**.

Market research is used to gather information about three facets of the total marketing effort. These areas, as shown in Fig. 15-28, are the:

- Market.
- Product.
- Marketing system.

Customers are the key to the marketing effort. Market research is used to locate them. Their

attitudes toward products are measured. This information helps in product development, advertising design, and product pricing.

The company must also gather information about the product. They need to know what products are selling; what changes in the product are wanted by customers; and product size, color, and style preferences. Also, future trends must be predicted.

Finally, the companies use market research to measure the success of their selling efforts. They will measure the effectiveness of advertising and selling programs. Their distribution system will be studied as well.

Market research is conducted in three basic ways: historical, survey, and experimental. *Historical research* uses company and industry records to gather information. Sales records are analyzed to determine product trends. Customer complaints are used to determine product development needs.

Survey research seeks information from the customers. They may be asked directly, as some companies do in shopping malls. Questionnaires may be mailed to a sample (a selected group) of customers. In some cases, telephone calls are used. Another source is the warranty card included in a new product. Customers are asked to answer questions that give the company information about themselves and why they bought the product.

Experimental research uses a controlled test to predict product success. Products may be introduced in a test market. Sales results of these products are used to predict regional or national success. This should help companies serve their customers better. You may have seen an advertisement for a product that said, "Available in a limited area." The product may be in a test market.

ADVERTISING

Advertising is the second function of marketing. It is designed to inform customers and persuade them to buy the product. Companies and agencies use two major types of advertising, Fig. 15-29:

- Product advertising.
- Idea or company advertising.

Product advertising is designed to promote a specific product. If successful, it will cause customers to seek out and purchase a selected item. You are impacted by product advertising every day. Product advertising can be found on billboards and television, over radio, and in newspapers and magazines.

Company and *idea advertising* are designed to cause people to think differently. Successful company advertising will cause people to accept a company. They will, hopefully, think positively about all the products made by a company. Examples of successful company advertising include: "You're in Good Hands with Allstate"; "At Ford, Quality is Job One!"; and DuPont's "Better Things for Better Living."

A good idea advertisement will make us behave differently. Successful idea advertising will cause you to "Buckle up," "Keep America Beautiful," or "Just Say NO!"(to drugs).



Fig. 15-29. Advertising may promote a company name or an idea. It may also promote a product. (Ad Council, Ohio Art Co.)

SALES

The actual exchange of products for money is called **sales**. This important marketing effort involves two major activities:

- Sales planning.
- Sales operations.

Sales planning is the action that is done before the product is sold. It is the coordinated plan for selling the company's output. Sales planning seeks to have the right product in the right place at the right time, at the right quantity and price, Fig. 15-30.

This may seem like a lot of "rights," but marketing is a balance between supply and demand. It involves having a product people want, when they want it, and where they want it. Think for a moment. Do you buy notebook paper? Where do you buy it? When do you buy it? Would it be wise to sell notebook paper at a flower shop? How often do you go there?

Sales operations are the actual selling of the product. Remember, you are studying manufacturing, so the salespeople call on wholesalers, retailers, and other companies. You seldom buy a product from a salesperson employed by a manufacturer.

Sales operations involve selecting and training a sales force. People who enjoy meeting people and those with an ability to communicate information and persuade people are selected. The salespeople must then be taught to complete, record, and communicate sales.

DISTRIBUTION

Getting the product to the consumer is called **distribution**. Often, this poses a major challenge for a manufacturer. The product is made in one location, but the customers may be spread across the country. The route the product travels from the producer to the consumer is called the *distribution channel*.

Consumer products follow one of at least three distribution channels, Fig. 15-31. The manufacturer may sell directly to the customer. Salespeople, representing the company, may call on the customers, or the customers may receive catalogs in the mail. This system is called *direct sales*.

In the second system, the manufacturer sells products to the retailer. The retailer then sells them to the final customer. This system is used when the manufacturers want to control the number and quality of the outlets for their products. An authorized or franchised dealer usually receives products in this manner.

In the most common system, manufacturers sell products to a wholesaler. The wholesaler buys products from many different manufacturers to develop a product line. The wholesaler calls on retailers and sells products from his or her line.

In this system, manufacturers seldom know who sells their products. This system works well with high volume and low-priced goods. Just think how many hardware stores there are. A manufacturer could not afford to have a salesperson call on each of them. However, it is possible to have salespeople frequently call on the major hardware wholesalers. Likewise, a

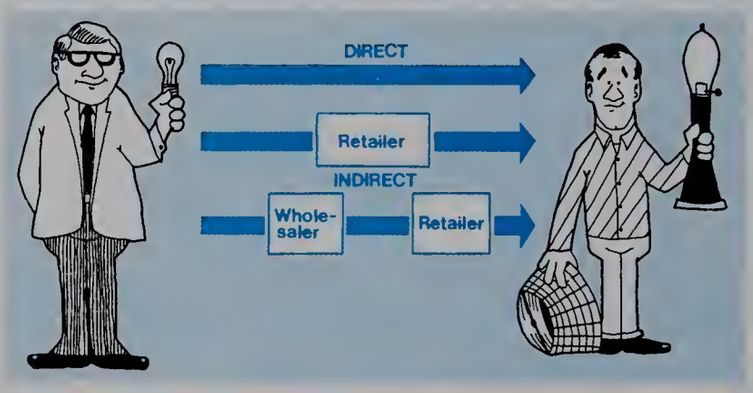


Fig. 15-31. These are the normal channels for consumer goods.

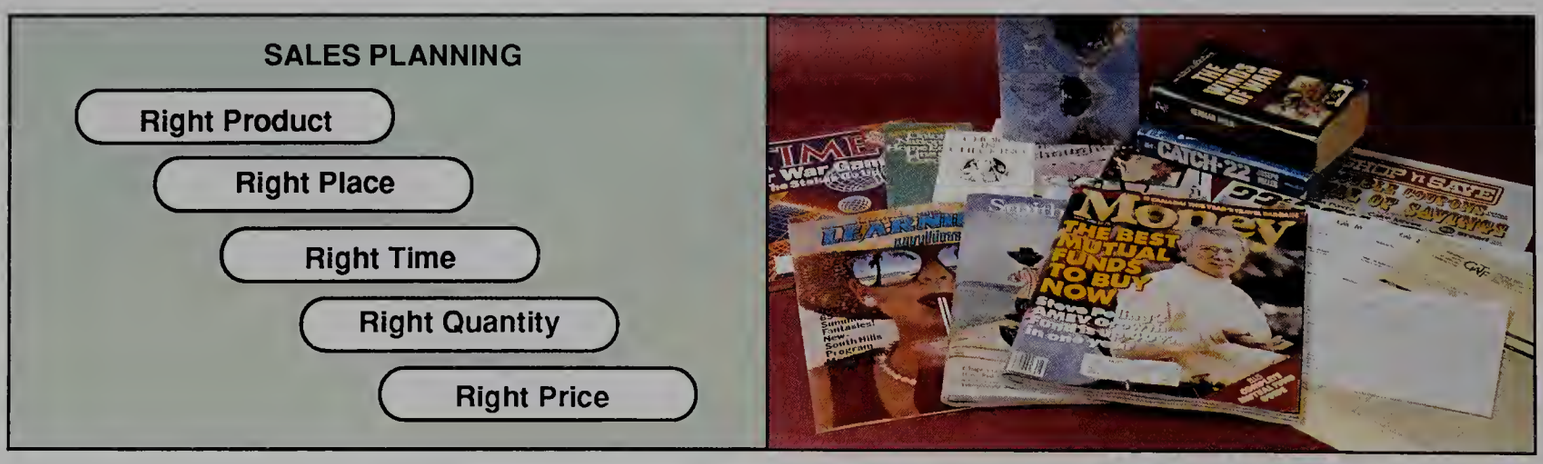


Fig. 15-30. All these elements of sales planning must be present for efficient product sales.



Fig. 15-32. Two major types of marketing are industrial marketing and retail marketing.

wholesaler with a large variety of hardware items can afford to call on each hardware store.

TYPES OF PRODUCTS

The end result of marketing is income from product sales. This income is generated from three basic types of products. These are consumer, industrial, and military.

Consumer products are purchased by the general public. They are the products that you see in local stores. They are ready for the "average citizen" to use.

Industrial products are the materials and equipment that are purchased by manufacturing, construction, transportation, and communication companies. They are used in conducting the company's business. They may be tools and machines, or they may be the materials used to produce products or provide services.

Military products are the tools of war. They are machines and materials used by military operations around the world.

Each of these types of products can be divided into two classes: durable and nondurable goods. *Nondurable goods* are those that have a short life. They are generally destroyed by or after use. Examples of nondurable goods are soap, food, paper items. Durable goods have a long life and wear out slowly. Automobiles, furniture, and sporting goods are durable goods. The line between these is not easily drawn. Clothing is considered a nondurable good by many people. However, many items of clothing have a fairly long life.

TYPES OF MARKETING

Products may move through two basic markets, Fig. 15-32. The first is **industrial sales**. The manufacturer will sell products to wholesale and retail companies. Store owners make product selections on different factors than you would use. They are concerned about profit margin and demand for the product. Retailers are interested in how well the product will sell. They are interested in the marketing support the manufacturer will provide.

The second type of market involves **retail sales**. This is where you buy a product. You may have several questions like: How well will the product work? How much maintenance and service will be required? How long will the product last? How much does the product cost? The product selection is then made on individual, personal factors.

SUMMARY

Research and development activities will result in a idea that is represented in a model and a set of specifications. These items communicate the designer's intent to the next product-centered activity: production.

Production involves all the activities that plan for and complete the production of products. These products must meet stated standards and human needs. The goal of the production area is to produce the best product with the least amount of materials, labor, and machine time.

Marketing activities encourage the flow of goods from producer to consumer. They gather information about the market. Then they promote, distribute, and sell the product.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

advertising
applied research
assembly drawings

basic research
consumer products
continuous manufacturing
custom manufacturing
detail drawings
development
dispatching
distribution
engineering testing
expediting
flexible manufacturing
industrial products
industrial sales
inspection
intermittent manufacturing
manufacturing engineering
market research
military products
mock-ups
product engineering
product-centered activities
production planning and control
prototypes
quality circles
quality control
research
retail sales
routing
sales
scheduling
specification sheets
systems drawings

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Which of the following are product-centered activities?
   a. Financial affairs.
   b. Research and development.
   c. Industrial relations.
   d. Marketing.
   e. Production.
2. What is the difference between a mock-up and a prototype?
3. Which of the following types of drawings provide production information about a single part?
   a. Detail drawings.
   b. System drawings.
   c. Assembly drawings.
   d. None of the above.
4. List the four functional areas of production.
5. True or False? Custom manufacturing uses special-purpose machines to provide large quantities of like products.
6. List the five major tasks of manufacturing engineering.
7. Encouraging the flow of goods from the manufacturer to the customer is called _____.
8. List the six steps involved in marketing products.
9. Describe the purpose of sales planning.
10. The route a product travels from the producer to the consumer is called the _____ _____.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Complete the line or custom produced product you began in Chapter 13. Through group discussion, develop a list of major advantages and disadvantages for custom manufacturing and line production.
   a. Decide if the discussion is to be informal or organized.
   b. If organized, it is suggested you elect one class member to chair the meeting.
   c. Have members suggest items that are advantages.
   d. Have members suggest items that are disadvantages.
   e. Vote on the items (use a show of hands).
   f. Draw up a report including a list of the advantages and disadvantages.
2. Assume your class is going to make a paper airplane. Spend one day developing the product (research and development), one day producing it (production), and one day developing an advertisement and package for it (marketing). Prepare a report describing this experience.
3. Divide into five groups. Each group will develop a bulletin board for one of the five managed areas of activities. This display should inform people about what the area responsibilities are and its major subdivisions (functions). (Note: This activity extends through Chapter 16.)

16

CHAPTER

MANAGED SUPPORT ACTIVITIES

After studying this chapter, you will be able to:

- *Describe financial affairs and industrial relations as managed support activities.*
- *List and describe the three major areas of responsibility in financial affairs activities.*
- *Name and describe the three major programs involved in industrial relations.*

Personnel involved in the product-centered activities give birth to products. They develop and specify the product. They convert materials into new shapes using product specifications. They sell products to customers. However, they do not do these things alone. People in other areas support these actions. Managed support activities, Fig. 16-1, are:

- Financial affairs.
- Industrial relations.

Financial affairs manages money. Industrial relations focuses on the people side of the enterprise. Let's look at these activities separately.

FINANCIAL AFFAIRS

Perhaps you have heard the saying, "It takes money to make money." It is generally used when talking about people. However, with a slight change it can apply to enterprises as well: "If money is properly managed, an enterprise will make money."

Money is a fundamental resource for all companies. It takes money to start a company, secure resources, produce products, and sell products to customers.

Money is important, but profits are essential. A company will be profitable only if money is used wisely. An enterprise will stay in business only if it makes a profit. Manufacturing companies make money from a series of activities. See Fig. 16-2. They identify consumer needs, design products, and develop manufacturing systems. Then they produce

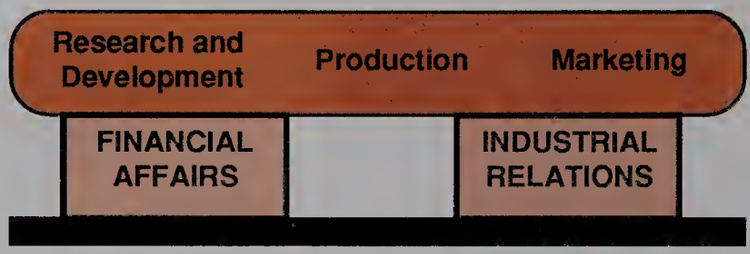


Fig. 16-1. The financial affairs and industrial relations areas support the product-centered areas of a company.

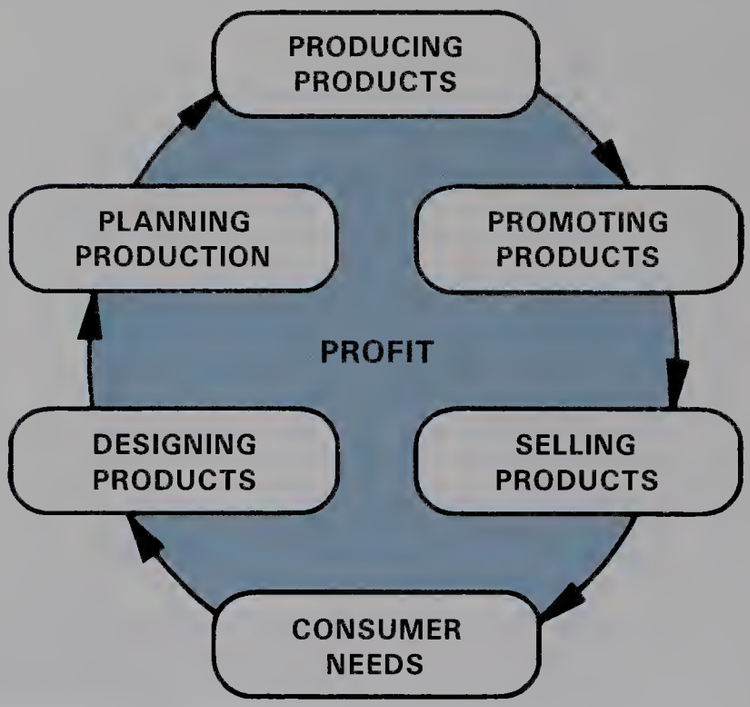


Fig. 16-2. Profits are earned when a company efficiently manages its operations and meets customer needs.

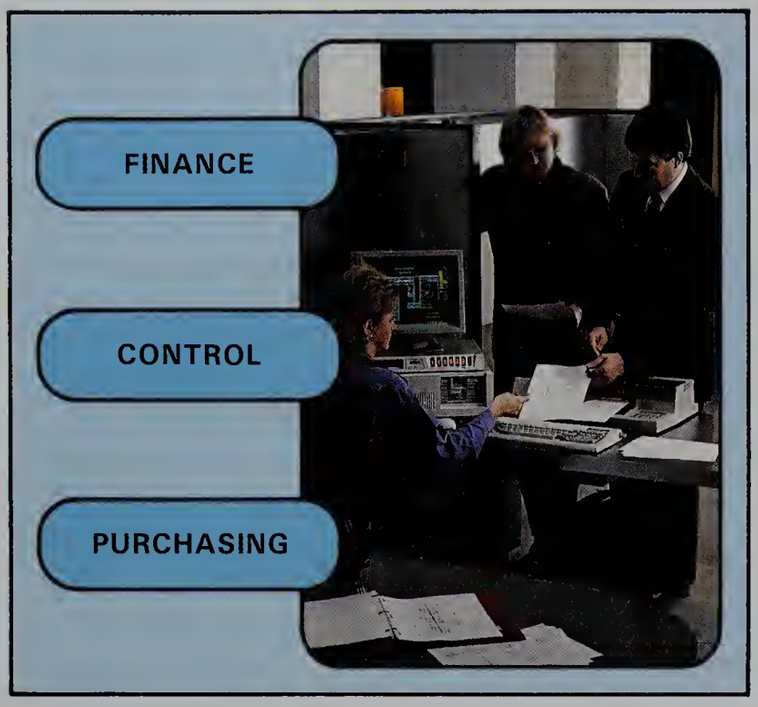


Fig. 16-3. Functions of the financial affairs areas are shown here.

products, advertise the company and its products, and sell products in the marketplace.

One activity is responsible for planning, coordinating, and controlling profits. This activity is called financial affairs. Personnel in this area manage the company's financial resources. They have responsibilities in three major areas. These, as shown in Fig. 16-3, are:

- Finance.
- Control.
- Purchasing.

FINANCE

Profits do not just happen. They are planned. **Finance** is the planning function of the financial affairs area. Finance personnel plan for acquiring money and using available funds. These plans are part of a series of events that enterprising people use to change ideas into products. These events include:

1. Determining financial needs.
2. Raising required money.
3. Allocating money to various company activities.

Determining financial needs

A corporation comes to life when it receives a charter from a state. The charter gives the company certain rights. One of these is the right to raise money. This money can be obtained by selling stock (ownership) or from borrowing.

However, even before the company is born (chartered) it will need money. Legal fees must be paid. Organizing officers require salaries. Early product development for the prospective company must be financed. State incorporation fees must be paid.

The early days of a manufacturing enterprise also have high demands for money. New products must be produced before sales income can be expected. Materials must be obtained. Buildings and equipment must be purchased or rented. People must be hired to operate the equipment. Managers must be employed.

Even mature companies face these financial demands as they introduce new products. Expansion means paying for new plants, equipment, materials, and personnel.

Raising money takes planning. Each element must have a cost attached to it. Only then can a company know how much money it must obtain.

Raising money

Determining the financial needs of a company is only a start. The funds must be raised. Two basic avenues are available:

- Equity financing.
- Debt financing.

Equity financing involves selling portions of the company's ownership. In a corporation, this ownership is called *stock*, Fig. 16-4. A share of stock is an equal portion of ownership. For example, assume you own 1000 shares of stock in XYZ Corporation. If there are 100,000 shares outstanding, you own 1/100 of the company.



Fig. 16-4. Stock certificates represent ownership in a corporation. (New York Stock Exchange)

Debt financing involves borrowing money. Companies use two types of debt: loans and bonds. They may obtain a **loan** from a bank, insurance company, or other financial institution. The company agrees to pay a specific rate of *interest*. This rate is generally tied to the *prime interest rate*. This is the rate that the bank's very best corporate customers pay. Companies that pose a higher risk will pay rates above the prime rate.

During the life of the loan, the company will pay back the *principal* (original loan). Loans are generally fairly short-term. The length of time is often one to five years.

Bonds are often sold to meet longer-term financial needs. A bond is a certificate of indebtedness (statement of debt) issued under the seal of the corporation. It usually matures (comes due) in 20 to 30 years. During that period, the company generally pays a set interest rate on the face value of the bond. These payments are made quarterly or semiannually to the bondholder, Fig 16-5. The bondholder will receive the value of the bond at maturity. Special bonds, called *zero-coupon bonds*, pay the bond value and all the interest at maturity.

Allocating money

The company must use the money raised from the sale of ownership, loans, and product sales wisely. There is usually a greater need for money than there are funds available to meet those needs. Finance personnel set priorities for the financial resources. They consider each proposed use of money. Typical questions addressed are:

- How will the proposed action or product impact profits?
- Is the money available sufficient to complete the project? If not, from where will the additional money come?
- Will the project or product contribute to company growth and stability?
- How much risk is involved in the project?
- Is the risk justified in terms of costs and profits?
- Will the company get the investment back? How soon will this happen?

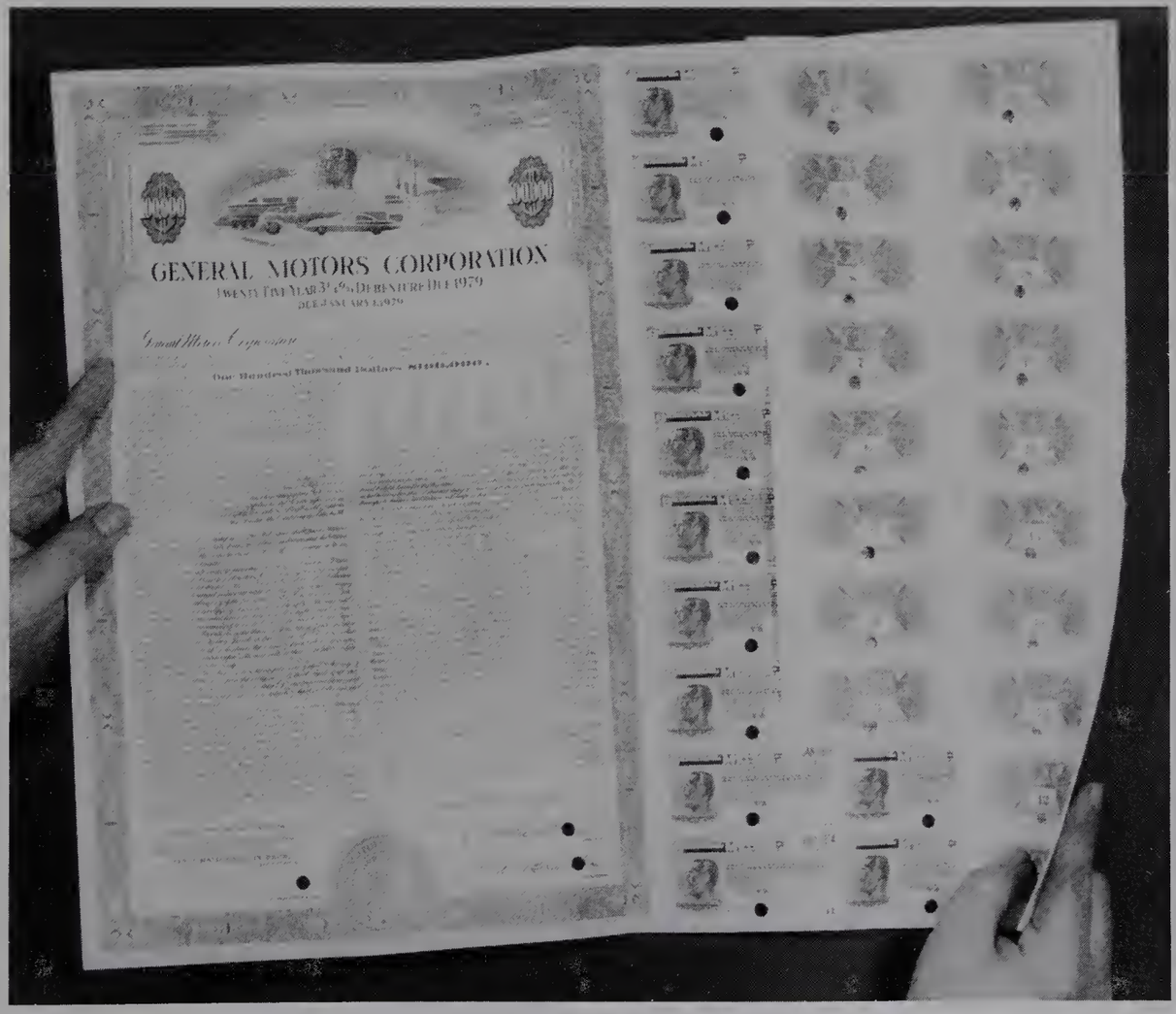


Fig. 16-5. Bonds are a special type of loan. Sometimes, the owner exchanges a coupon from the bond for an interest payment. (General Motors Corp.)

All business decisions have a financial impact. Each action must be subjected to financial analysis. Only then can management show that it is wisely using the financial resources of the company.

CONTROL

How much did the company make last year? How much does it cost to manufacture that product? Is the plant in Chicago making money for the company? Can the company expect to make a profit next year? These are typical questions facing corporate management. Accurate answers can be developed if the company has sound financial projections (budgets) and records.

The financial affairs area that maintains financial records and develops and monitors budgets is called **control**. Personnel in this area complete three major functions, Fig. 16-6:

- Budgeting.
- General accounting.
- Cost accounting.

Budgeting

Company actions are generally planned, and all plans can be communicated in financial terms. For example, you might plan to make 100 CD holders. You could develop drawings. These plans would communicate the size and shape of the product. You could develop process charts and tooling drawings. These would be part of your production plans. You could also develop plans for marketing the product. However, you might ask two questions: "How much will this cost?" and "How much will I make from this endeavor?" These questions are answered by budgets.

A **budget** is an estimate of revenues (income) and expenditures (outgo) for a definite period of time (monthly, quarterly, or yearly). Budgets provide valuable information needed to make good management decisions. A company often has several budgets, Fig. 16-7. These budgets may cover specific products, activities (engineering, production, marketing, etc.), plants, or the entire company.

A manufacturing company will develop at least five different types of budgets. These are:

- *Sales budget:* This is the projected income from the sales of various products and services. It is based on a projection of sales levels for each product or product line.
- *Production budget:* This is an estimate of the cost of labor, materials, equipment, and factory overhead (maintenance, utilities, and supervision) directly related to making the product. This budget is based on a level of production indicated by the sales budget.
- *Administrative budget:* This is an estimated cost of operating the corporate office, product development activities, and the marketing program. This budget lists those items generally called general *overhead.*
- *Financial budget:* This is an estimate of the income and expenses expected during the budget period.
- *Master budget:* This is a summary of major income and expense categories detailed in more specific budgets. This budget provides an overview of total company operations.

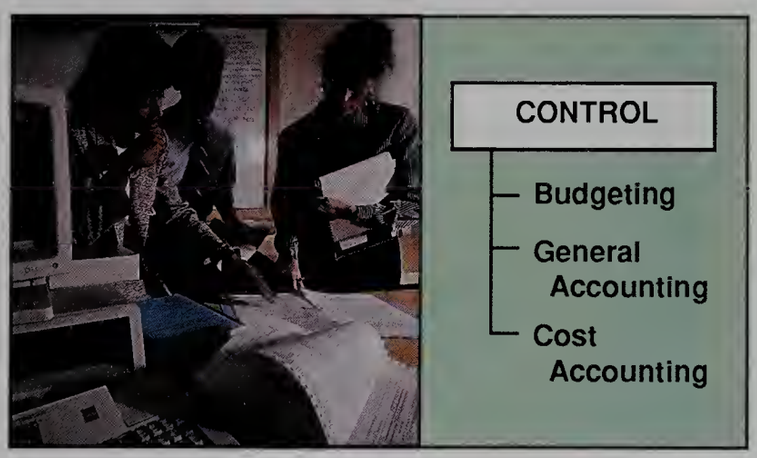


Fig. 16-6. These are tasks of the financial control function. (Union Pacific)

General accounting

All companies must maintain formal financial records. They detail every financial transaction made by the company. All income and expenses are recorded and documented. These records are part of general accounting. They are used to:

- Prepare periodic financial reports.
- Keep track of the money owed by the company to suppliers, workers, and governmental agencies.
- Keep track of the money owed to the company by customers.
- Report earnings of the enterprise.
- Determine the financial worth of the company.
- Prepare tax forms.

Cost accounting

Few companies are single-product enterprises. Most produce a variety of products. They do this in several locations. Management must know the cost of producing each product and operating each plant. This is the task of cost accounting personnel. These people use financial records to set the actual operating cost for company operations.

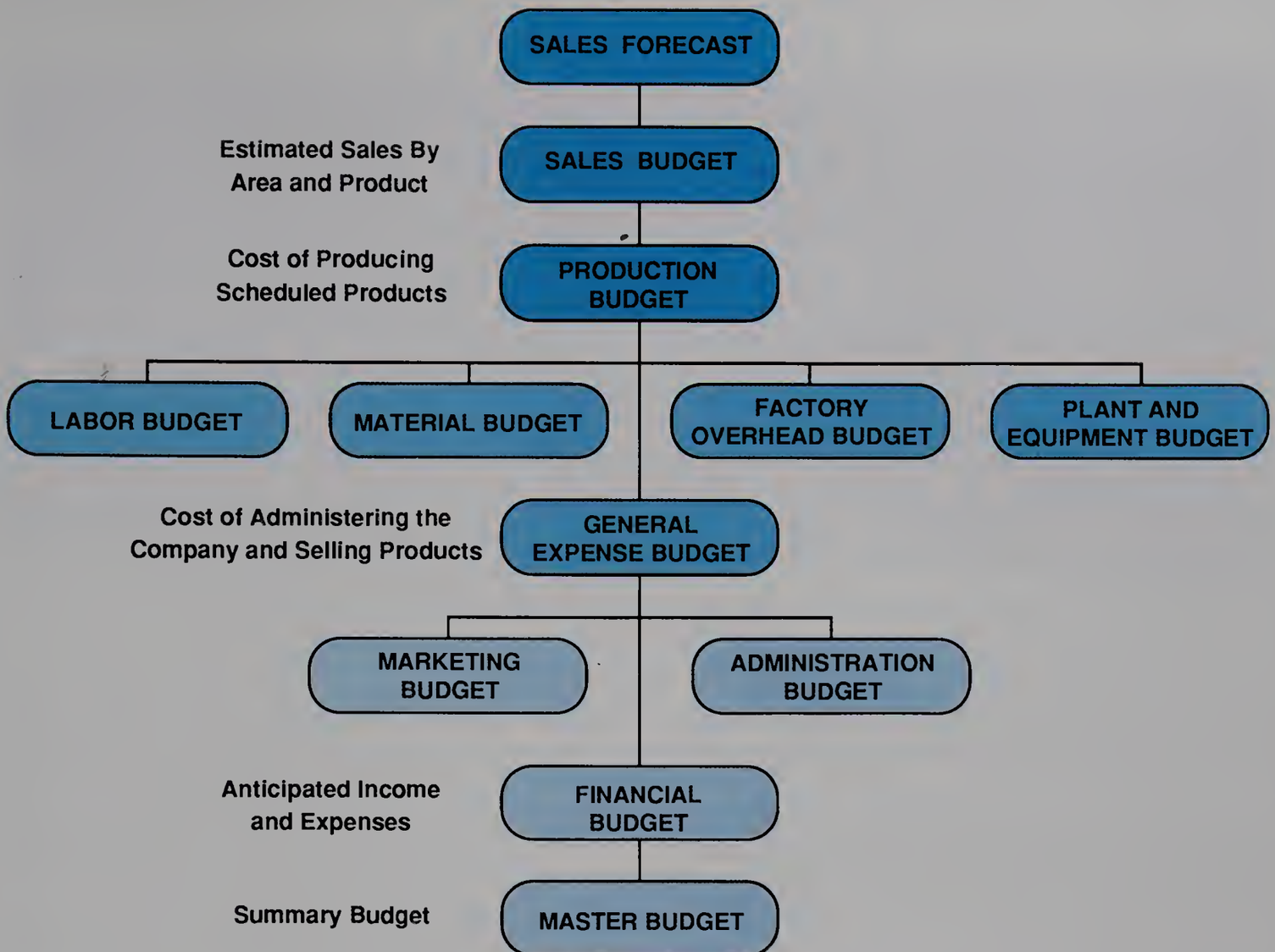


Fig. 16-7. Budgets are estimates of sales, income, and expenses.

Cost accounting systems charge every expense to a specific category. The categories may be a product or a plant. They may also be a department in a plant or any other unit. These units are called *profit centers*. The cost accounting system targets which profit centers are making money and which are not.

With accurate cost data, managers can establish selling prices for products, check on the profitability of products, and measure the efficiency of company operations. They can then allocate money to profitable activities and close marginal or money-losing portions of the company.

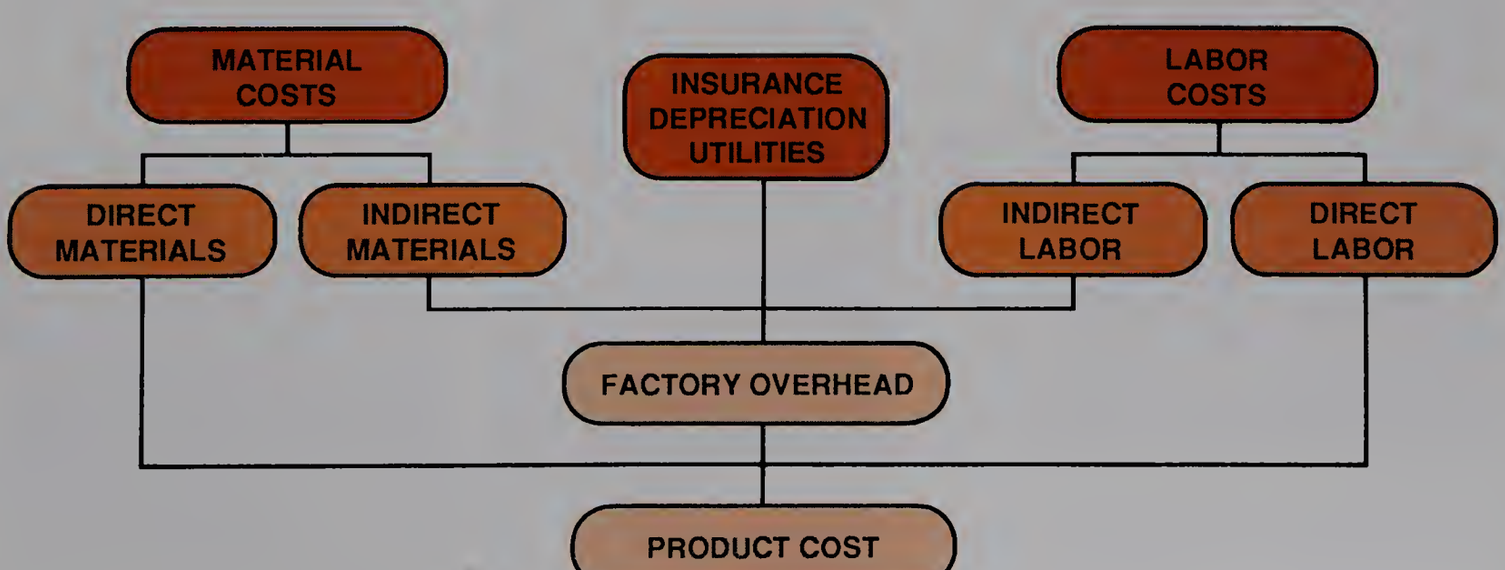


Fig. 16-8. Many different costs make up the total cost of a product.

The costs for producing a product can be divided into three major categories, as shown in Fig. 16-8. These are:

- Materials:
  a. **Direct materials:** These are materials that become part of the product.
  b. **Indirect materials:** These are supplies used in producing the product (abrasive papers, cutting oils, etc.).
- Labor:
  a. **Direct labor:** This is labor used to supervise or perform the processing of materials into finished products.
  b. **Indirect labor:** This is labor that serves direct labor activities (maintenance, clerical, janitorial, etc.).
- Overhead:
  a. **Production overhead:** These are all production costs that are not direct labor or materials. This includes indirect materials and labor.
  b. **General overhead:** These are corporate product development, marketing, and administrative costs.

If a number of products are being produced in a plant, the overhead costs must be divided among each product. Only then will an accurate cost for each product be developed.

PURCHASING

The third financial affairs activity is purchasing. **Purchasing** is the buying of equipment, supplies, materials, and utilities needed to produce scheduled products, Fig. 16-9. People in purchasing must determine the physical needs of the company. Then the supplier of the materials, equipment and services must be identified. The supplier with the best quality, price, and delivery date is selected. The item is ordered and the vendor (supplier) is paid upon delivery.

Purchasing actions are often designed to have materials arrive at the time they are needed. This way, the company does not maintain a costly inventory of purchased parts and raw materials. This system is called *just in time (JIT)*. The item arrives just in time to be used.

INDUSTRIAL RELATIONS

Companies have developed many systems and processes for making manufacturing efficient. Computers and automatic machines are entering the workplace in growing numbers. Yet, people remain the single most important factor, Fig. 16-10.

In order to succeed, all processes, plans, systems, and theories need people. Systems and processes are useless without leaders and followers. Some people must have vision and the ability to lead the company to higher goals. Other people must be willing to work in teams to reach these goals.

Every company has programs that deal with people. They develop people's ability to complete assignments. They also foster positive relations between management, the workers, and the public. These programs are part of the managed support activity



A B C

Fig. 16-9. Purchasing personnel purchase: (A) the materials, parts, and supplies; (B) machines and equipment (American Iron and Steel Institute); and (C) utilities and services.



Fig. 16-10. Even with complex data processing centers, people are still the key to company success. (General Motors Corp.)

called industrial relations. This area is responsible for managing all people-centered activities. These activities may be divided among three major programs:

- Employee relations.
- Labor relations.
- Public relations.

These programs are responsible for developing an efficient work force. They are also responsible for maintaining positive human relations.

EMPLOYEE RELATIONS

Human resources are key to the success of a company. **Employee relations** is responsible for developing this vital resource. This task involves more than simply hiring and firing workers. It includes recruiting qualified workers, helping them develop their abilities, and rewarding them for quality performance. It also requires attention to the health and safety of the work force.

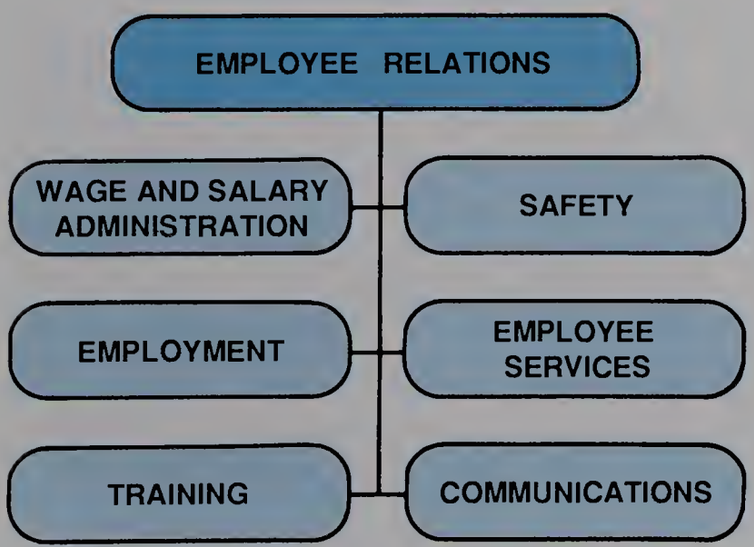


Fig. 16-11. These are tasks of employee relations.

Employee relations is a challenging area. Many companies divide it into specific tasks or jobs including, Fig. 16-11:

- Wage and salary administration.
- Employment.
- Training.
- Safety.
- Employee services.
- Communications.

A new term for many of these activities is **human resource development (HRD)**. This name indicates the focus of these tasks, which is to help people grow with their jobs and the company.

Wage and salary administration

Companies must hire workers. What kind of skills should these people have? What will they do on the job? How much are they going to be paid for their time and effort?

Wage and salary administration activities describe, analyze, and classify jobs. This may be done by the five-step process shown in Fig. 16-12.

Job analysis is the first step in a wage and salary study. It describes jobs in terms of:

- What work is involved.
- How the work is accomplished.
- What knowledge and skill are required.

The results of this study are summarized in a job description. This statement lists the job title, duties, and qualifications. It also lists the tools and materials used on the job.

Job rating usually follows job analysis. It is a careful study of the requirements of all the jobs in the company. The jobs are reviewed in terms of skill, education, responsibility, and hazards. The goal is to place the jobs in a scale from most demanding to least demanding.

It is probably unwise to have a different pay rate for each job in the company. Therefore, the hierarchy of jobs is divided into groups. Later, each group will have a pay rate attached to it.

Job pricing picks up where job rating leaves off. This task attaches a salary or hourly wage to each job or job classification.

The actual pay rates are impacted by four factors. These are economic conditions, prevailing local pay rates, availability of qualified workers, and, in some cases, collective bargaining.

Task setting follows job pricing. This activity establishes a specific performance for each job. It may involve a production rate (100 parts per hour) or a work period (eight hours per day).

Wage control measures performance against the job requirements. It may involve punching a time clock, Fig. 16-13. In other cases, production rates are measured. Incentives, such as bonuses, may be paid for quantities produced above the established rates.

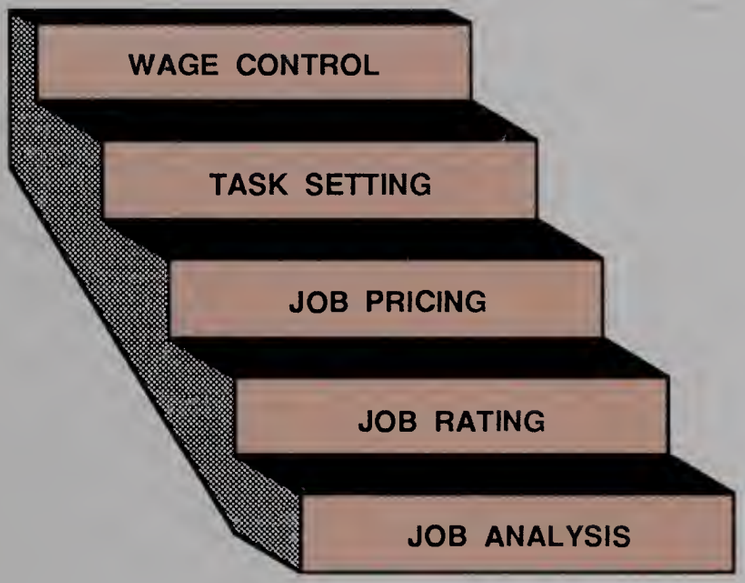


Fig. 16-12. These are the typical steps in wage and salary administration programs.



Fig. 16-13. Time clocks are often used as wage control devices. (ARO Corp.)

Employment

All enterprises must employ workers. People with the proper attitudes, skills, and knowledge must be recruited and selected. This task follows four basic steps. These, as shown in Fig. 16-14, are:

1. Determining personnel needs.
2. Attracting potential employees.
3. Gathering information about the applicants.
4. Selecting qualified individuals.

Determining personnel needs starts the employment process. This action is often triggered by an employee requisition, Fig. 16-15. This form is pre-

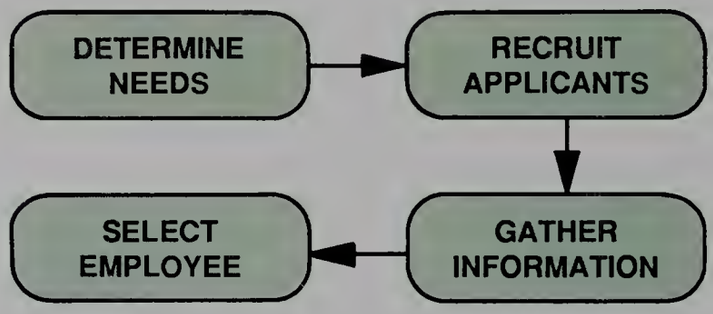


Fig. 16-14. These steps are often followed when hiring a new employee.

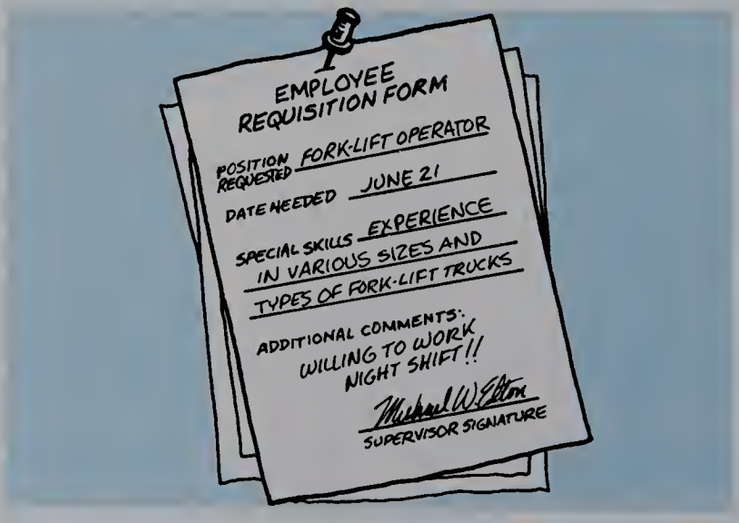


Fig. 16-15. An employee requisition alerts the employment office of a need for an employee.

pared by a manager and notifies the employment office of a vacancy in the company.

The employment personnel must then recruit potential workers, Fig. 16-16. Recruiting may involve advertising in newspapers and special audience magazines. Company personnel may visit technical schools and universities. Employment agencies and the company personnel files may also identify suitable workers.

Gathering information about the applicants is necessary to make wise employee selections. The potential workers will fill out an application. Previous employers are generally asked to verify work records and performance. In some cases, aptitude and performance tests are given.

This information is used to select qualified workers. These people are notified of their employment. They may receive an employment notice. This document tells them when to report to work, the job title, and the pay rate.

Training

Few people come to a company fully prepared to meet the challenges of the job. Most new employees need information and direction about the company and the job. This action is called training or employee development.

Almost all new workers receive **induction training**. This training gives people basic information about the company and its rules. It outlines general working procedures, pay policies, and other similar information. (Its name comes from a Latin word that means to "bring in.")

Managers often receive additional training in management skills, labor relations, and company procedures. They may be rotated through a number of positions to learn the scope of the company. Additionally, they may attend classes or training sessions.

Hourly workers may receive training in one of three ways. They may be given **on-the-job-training**, Fig. 16-17. This training takes place at the workstation and is given for simple, routine jobs. More complex jobs require formal classroom and technical training called **vestibule training**. Highly skilled workers are developed by **apprenticeship training**, Fig. 16-18. This combination of classroom and work



Fig. 16-16. Applicants may be found in four basic ways.



Fig. 16-17. New employees may receive on-the-job training from supervisors. (Xerox)



Fig. 16-18. Apprenticeship training prepares workers for high-skill, high-knowledge jobs. (Goodyear Tire and Rubber Co.)

experience takes several years and involves studying under people with years of experience.

Learning and training are never complete for any employee. The rapidly changing nature of manufacturing requires that workers receive constant training and development opportunities.

Safety

Safety in manufacturing is everyone's concern. People can be injured by their own or by other worker's carelessness. Additionally, the financial health of the company can be endangered due to the rising costs of accidents.

Out of human and financial concern, most manufacturing companies conduct safety programs. An adequate safety program addressees four major points:

- *Equipment* must be designed for safe operation. Guards must be in place. Controls must be located to encourage safe operation, Fig. 16-19. Tooling must be designed with safety in mind.
- Workers must be *educated* in safe practices. Proper operation procedures must be taught. The importance of safety equipment, such as safety glasses, hearing protectors, gloves, safety shoes, must be stressed. The safe operation of equipment is not a natural thing. It MUST be taught.
- Workers need *encouragement* to work safely. A positive attitude toward safety must be developed. This may involve safety meetings, posters, and awards.
- The total safety program must be *enforced*. A safety program must be supported by all employees from the plant manager to the employee on the line.

A good safety program is concerned about each person's welfare. It should encourage each person to:

- Work safely.
- See that others work safely.
- Report safety hazards and violations.

Employee services

Building a good work force goes beyond efficient employment and training practices. It depends on workers with a positive attitude about the company. This attitude can be improved by good employee services. These include health and medical benefits; holidays and vacations; retirement plans; and disability and unemployment plans. Such items are often called **fringe benefits** or indirect labor costs. They are those things that the company pays for beyond the basic salary or wage.

In addition, companies often provide social and recreational opportunities. They may sponsor picnics, bowling teams, trips to ball games, and other outside-work events.

Communications

Communications is an important employee relations function. Communications designs and promotes the flow of information between managers and workers. It involves suggestion systems, company newsletters, pay envelope flyers, and company bulletin boards, Fig. 16-20. The purpose of communications is to reduce fear, unrest, and mistakes caused by misunderstandings and lack of information.



Fig. 16-19. Equipment must be designed for safe operation. (Parker Hannifin Corp.)



Fig. 16-20. Company newspapers help workers to stay informed about the company.

LABOR RELATIONS

A recent report suggests that the best workers and managers are those who enjoy work and have fun. This does not suggest that work is a game. It does say that contributing to a company's success can be rewarding.

However, goals of workers and management are not always in harmony. Management may want more production, while workers want more vacation time. These goals may conflict. Successful companies work through their worker-management problems. The area that coordinates these activities is called **labor relations**.

Many manufacturing companies have labor unions. These organizations represent the worker's views on pay rates, hours, and working conditions. Unions and managers present a unique type of labor relations. Generally, it is more formal and organized. Typically, these groups interact for three major purposes:

- Union organizing activities.
- Collective bargaining.
- Grievance adjustment.

Union organizing activities

Organized labor's role in manufacturing is important. The unions place constant pressure on management to recognize and deal with the needs and wants of workers.

Generally, workers expect certain things from their jobs. They want recognition, good pay and working conditions, vacations and holidays, health and life insurance, and pensions or retirement allowances. These things cost money. They are also open to judgments. What is good pay? How much medical insurance is needed? Who should pay for it?

Manufacturing management must juggle various responsibilities. Among them are:

- Earning a profit for the owners of the company.
- Providing a humane work environment.
- Preserving the environment.
- Providing products that serve the needs of customers.

The balance between these responsibilities may cause problems. The workers may feel they are not receiving their fair share. A worker can do little alone, but in numbers, there is strength. Workers may choose to form a **labor union**. The role of a labor union is to present a united voice for workers. It balances the strength of management with the strength of a unified work force, Fig. 16-21.

The union organizing effort is the first major contact between management and labor. The union must establish an effective structure and organization. It must gain and maintain a place in the plant. The stronger the union is, the stronger its voice in setting wages, hours, and working conditions.

The organizing effort must establish the right of the union to represent workers. It also sets the type of



Fig. 16-21. Managers are willing to negotiate a labor agreement with union representatives because the union speaks for a large number of workers. (United Steelworkers of America)

union security in the company. The three common types of security are:

- **Open shop:** Workers are free to join or not to join the union. The union is least secure in the open shop. Membership is not guaranteed, and workers can quit the union at any time.
- **Agency shop:** Both union and nonunion workers pay dues. Nonunion workers are not union members and do not participate in union activities. They do, however, receive all the benefits gained by union action.
- **Union shop:** This is the most secure type of agreement allowed by law. It requires all workers in the bargaining unit to belong to the union. Management may hire anyone they choose. All new employees must join the union after a specified period of time. Federal law provides for a minimum of 30 days before membership can be required.

Collective bargaining

Once a union is established, management is required by law to enter into **collective bargaining**. Collective bargaining is the process in which workers, through their union, meet with management and work out a contract. Both sides present proposals for wage rates, hours, and working conditions. Each side meets proposals with counterproposals until an agreement is reached.

If an agreement cannot be reached, the workers may strike, Fig. 16-22. This is an economic action. The workers withhold their labor. This deprives the company of production. Without production, there are no products and no sales income.

Once an agreement is reached, it is presented in the **labor agreement** or union contract, Fig. 16-23. This is a legally binding document that describes:

- Management prerogatives (rights).
- Bargaining unit recognition and labor union membership.
- Wage rates and policies.
- Hours of work.
- Vacations and holidays.
- Layoff and recall procedures.
- Working conditions.
- Grievance procedures.
- No-strike clause.
- Contract term (length).

Grievance adjustment

All labor agreements have a procedure for solving disagreements between labor and management, Fig. 16-24. This is called the **grievance procedure**.

A grievance is a disagreement over the interpretation of a clause in a contract. (A clause is a section or an item of a contract.) Since a contract is developed by one set of people, and it is put into action by another group, misunderstandings may result.

Workers who feel that they are not treated fairly can file a grievance. The grievance procedure is much like our court system. There are various levels in the procedure. The findings at each level can be appealed to a higher level. The highest level then makes a final decision.



Fig. 16-22. Strikes place economic pressures on the company to settle work issues with the union. (United Steelworkers of America)

PUBLIC RELATIONS

An enterprise desires to be accepted by a community. It wants to be seen as a positive force on local, state, and national levels. To gain this acceptance, a company first puts "its best foot forward." It then informs people of the benefits and contributions of the company. Providing this information is the task of **public relations**.

A good public relations program has a focus. It is directed to specific groups including:

- The community.
- The government.
- The shareholders.
- The general public.

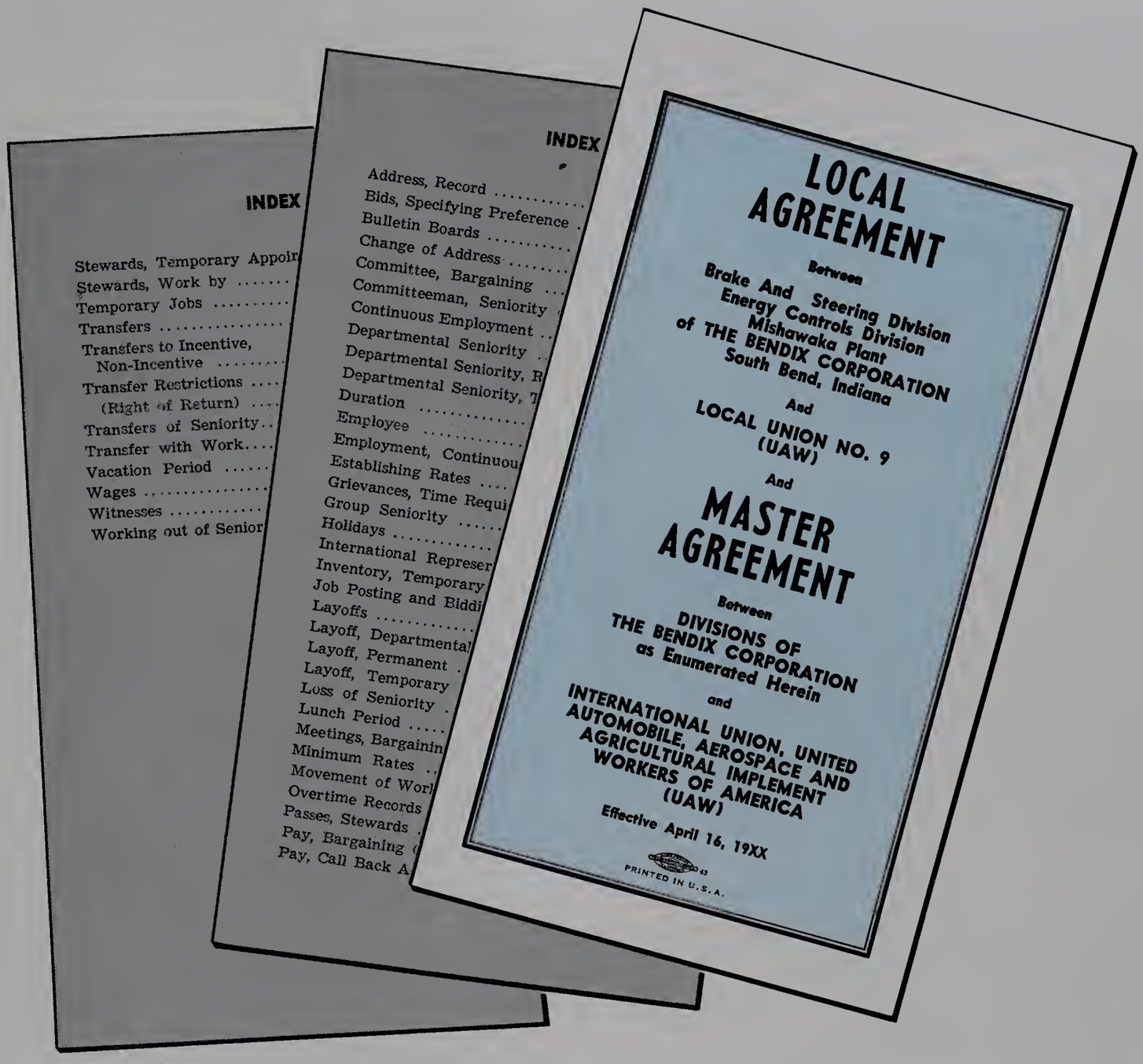


Fig. 16-23. Collective bargaining results in a labor agreement.

Good *community relations* may be essential for company success. A positive community image improves a company's ability to attract new workers and generate necessary political action. A company's community relations program often contributes personnel and money to local charities. It often issues information on the economic impact of company operations. It also publicizes company efforts to create jobs, improve the environment, and other actions.

Governmental relations includes all activities designed to acquire favorable local, state, and national political action. It includes the company's lobbying efforts. Remember, a company is an artificial being. Just as you have the right to talk to your elected governmental officials, so does a company.

Stockholder relations are those communication efforts directed toward the owners of the company. It provides information about the company's successes and future plans. Common tools for stockholder relations are the quarterly and annual reports.

General public relations are all the efforts to present the company to average citizens in a favorable light. It includes free booklets, study materials for schools, free films, and sponsorship of public television programs. Many of the photographs in this book were provided by public relations departments of major companies.

Public relations should be seen as a positive activity. It is the right of every citizen to tell his or her story. Companies present their point of view and



Fig. 16-24. Grievances may arise over the interpretation of a labor agreement.

personal story through public relations programs. Good public relations programs present truthful and valuable information.

SUMMARY

Product development activities are supported by two major support areas. Financial affairs raises money; maintains financial records; and purchases materials, equipment, and services. Industrial affairs provides support through human services. It operates employee, labor, and public relations programs. These programs develop positive relationships between management and the employees and the public.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

agency shop
apprenticeship training
bonds
budget
collective bargaining
control
cost accounting
debt financing
direct labor
direct materials
employee relations
equity financing
finance
fringe benefits
general overhead
grievance procedure
human resource development (HRD)
indirect labor
indirect materials
induction training
job analysis
job pricing
job rating
labor agreement
labor relations
labor union
loan
on-the-job-training
open shop
production overhead
public relations
purchasing
task setting
union security
union shop
vestibule training
wage control

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List two managed support activities and describe their roles in the manufacturing system.
2. List the three major areas of responsibility in financial affairs activities.
3. True or False? Finance is the planning function of the financial affairs area.
4. The financial affairs area that maintains financial records and develops and monitors budgets is called _____.
5. Which of the following is an estimate of the cost of labor, materials, equipment, and factory overhead (maintenance, utilities, and supervision) directly related to making the product?
   a. Sales budget.
   b. Administrative budget.
   c. Production budget.
   d. Financial budget.
6. _____ is the buying of equipment, supplies, materials, and utilities needed to produce scheduled products.
7. Name and describe the three major programs involved in industrial relations.
8. True or False? Employee relations involves simply hiring and firing workers.
9. Explain how collective bargaining works.
10. Name four groups to which the public relations of a company is focused.

APPLYING YOUR KNOWLEDGE

1. On a chart, similar to the one in 16-A, list five ways the support-centered activities support the product-centered activities.

a. Review material in this chapter as necessary.
b. Secure from the library or resource center articles or texts about financial affairs and industrial relations.

2. Prepare a one-minute presentation about one of the functions of a managed support activity area.
3. Develop a bulletin board or display that will project a positive image of technology education (public relations).
   a. Collect and organize facts.
   b. Select illustrations, take photographs, or display items.
   c. Design the message and place it on the bulletin board or in the display.

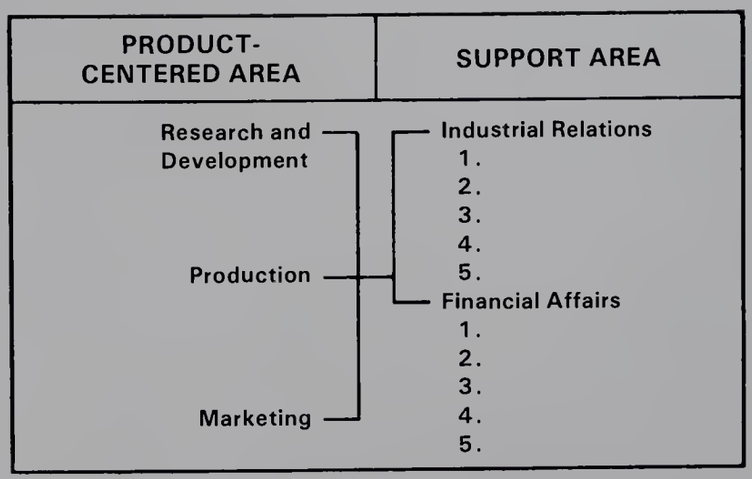
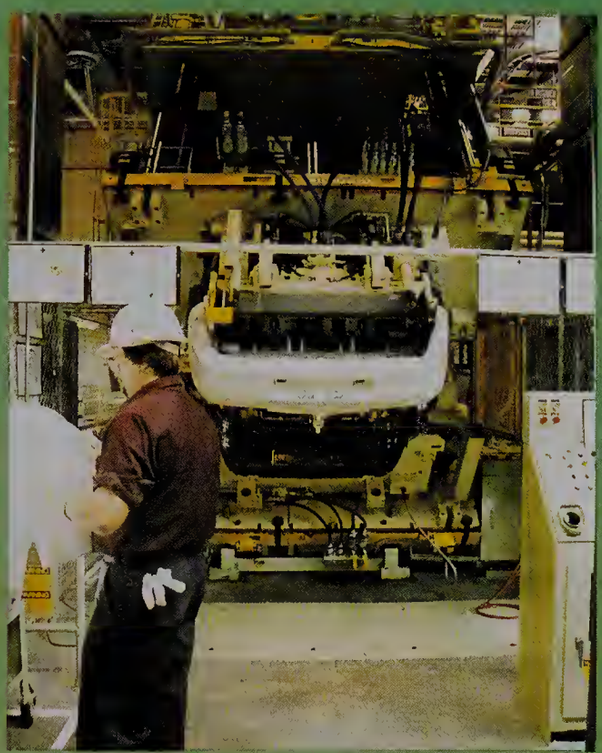


Fig. 16-A. Prepare a chart similar to this one on which to list ways support-centered activities support product-centered activities.



DIAMOND-STAR MOTORS



DIAMOND-STAR MOTORS



TEXACO, INC.



OHIO ART CO.

section 5

Manufacturing Enterprise

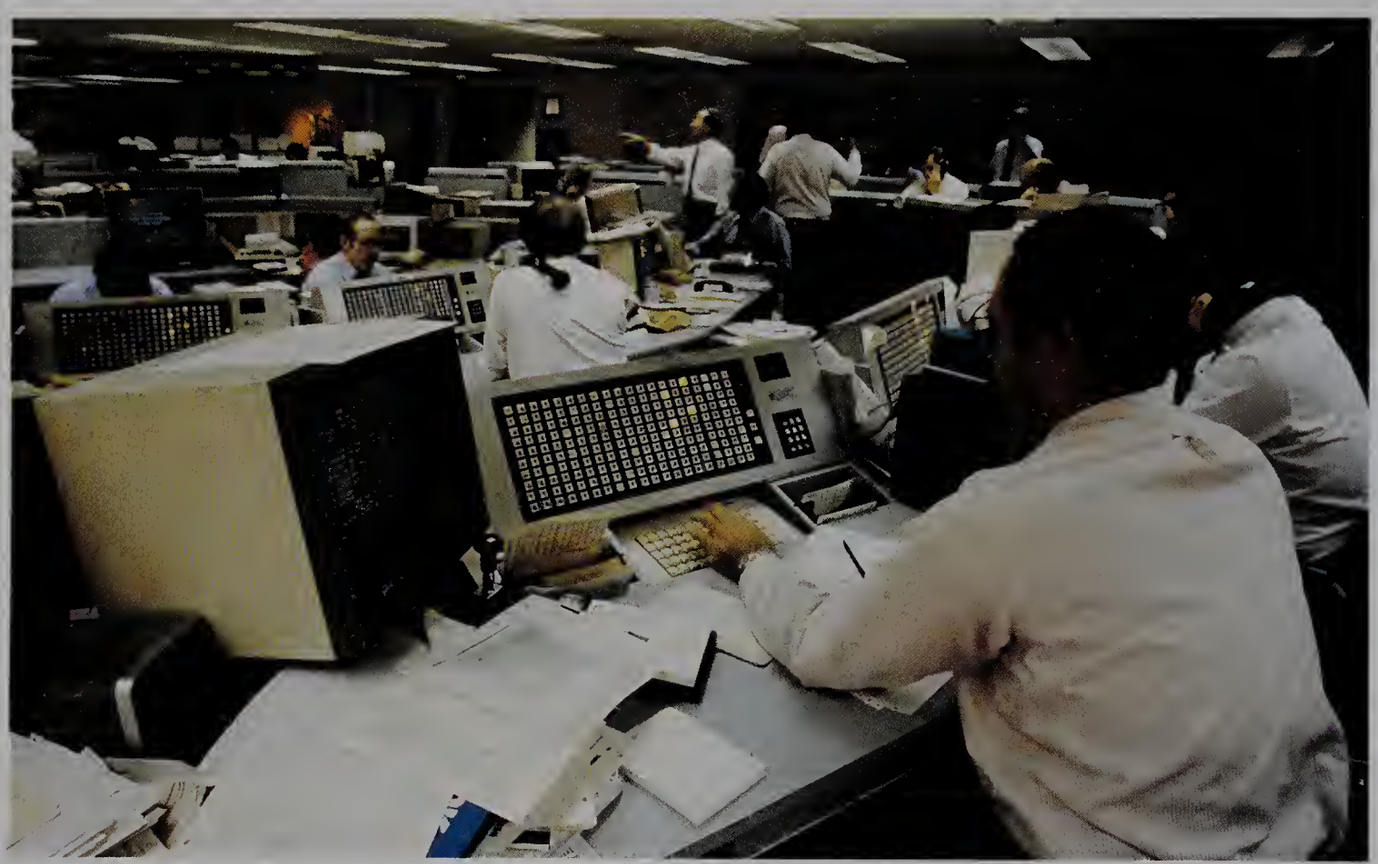
17. Organizing and Financing an Enterprise
18. Developing a Product
19. Developing a Production System
20. Obtaining Resources
21. Manufacturing Products
22. Organizing Labor Unions
23. Marketing Products
24. Maintaining Financial Records
25. Closing the Company



CLOROX CO.



DIAMOND-STAR MOTORS



Finance managers use data to predict future needs for money from loans and stock sales. (Sears, Roebuck and Co.)

17

CHAPTER

ORGANIZING AND FINANCING AN ENTERPRISE

After studying this chapter, you will be able to:
- *Explain how a legal company is established.*
- *Describe how a managerial structure is developed and organized.*
- *Name three ways an enterprise can be financed.*
- *Explain how budgets and break-even charts are used to estimate the income, expenses, and profits of a company.*

You think you may have a good product idea! Why not make some money on it? You could put it on the market. People may buy it, and you could become wealthy. This sounds easy, but it may be harder than you think. Many people have great ideas for new or improved products. However, an idea will "die on the vine" without a well-organized and financed effort. See Fig. 17-1. It takes the talents of many people to bring an idea to a customer.

This chapter will help you organize a student enterprise that reflects your industrial counterpart. Your enterprise will develop, manufacture, and market a product that people need or want. Included in this discussion are four major tasks faced by all beginning enterprises:
- Establishing a legal company.
- Developing a management structure.
- Financing the enterprise.
- Estimating income, profit, and expenses.

ESTABLISHING A LEGAL COMPANY

An enterprise must become a legal company before it can fully operate. The necessary licenses must be obtained for proprietorships and partnerships, or a corporation must be formed.

Almost all manufacturing companies are corporations. Therefore, forming this type of company will be explored. As you learned in Chapter 14, a corporation is an artificial being. It can own property, enter into a contract, be sued, sue other corporations, and pay taxes.

The corporation, like other beings, must be born. The corporate birth process leads to a **charter**. The charter is the corporation's "birth certificate." It is issued by one state and allows the company to operate in all other states.

Each state has its own incorporation laws and fees. However, certain steps, as shown in Fig. 17-2, must be followed.

PREPARE ARTICLES OF INCORPORATION

A certificate, or **articles of incorporation**, must be prepared, Fig. 17-3. This document is obtained from



Fig. 17-1. Chances are, this building houses a successful company. How did the company get started? Possibly, its founder had an idea for a useful product.

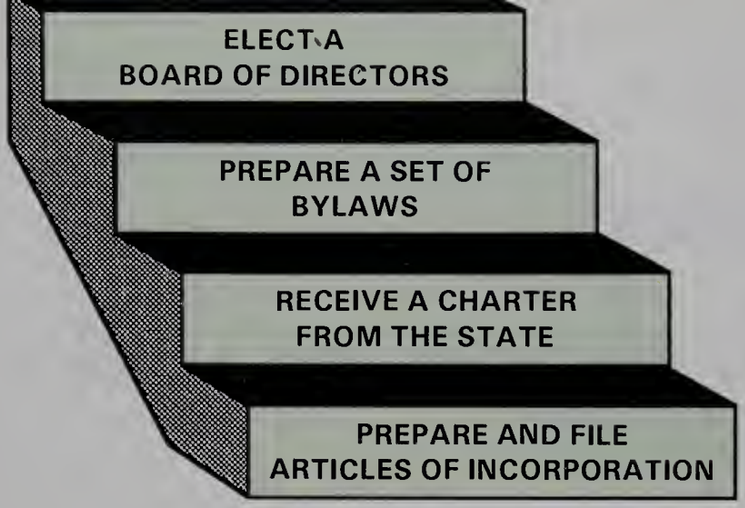


Fig. 17-2. The steps required to start a new enterprise are shown above.

the Secretary of State or a similar state official. This state officer should not be confused with the United States Secretary of State.

The articles of incorporation serve as the application for a corporate charter. The certificate usually requires:

- Name of the company.
- Proposed activities (purpose of the company).
- Names and addresses of the people forming the company (incorporators).
- Location of the company offices in the state.
- Value and type of stock to be issued.
- Additional information required by the state.



Fig. 17-3. The certificate of incorporation is carefully studied by state officials before it is approved and a charter is issued. (Boise Cascade Corp.)

RECEIVE THE CHARTER

The completed certificate is filed with the proper state office. An attorney for the company usually completes this task. The organizing company also pays a fee to the state. The fee varies from state to state, but it is generally based on the number of shares to be issued.

The certificate is carefully studied by state officials. The approved certificate becomes the articles of incorporation or corporate charter. It will generally be accepted if:

- The name of the proposed corporation is found acceptable.
- The certificate is properly completed.
- The purposes of the company are legal.
- All state laws are met.
- Incorporation fees are paid.

APPROVE BYLAWS

After the company is incorporated, the stockholders must complete the company organization process. They must elect directors to represent their interests. These corporate officials will set policy and give general direction to the company.

The incorporators must also develop a set of **bylaws**. These are the general rules of an organization. When approved by the stockholders, they will govern the general operation of the company.

The bylaws, Fig. 17-4, often include information contained on the corporate charter. In addition, the bylaws describe:

- Date and location of the annual stockholders' meeting.
- Date, location, and frequency of board of directors' meetings.
- List of corporate officers.
- Duties, methods of appointment, and term of corporate officers (principal managers).
- Number of directors, their duties, and their term of office of the directors.
- Types of proposals that must be approved by stockholders.
- Method for changing the bylaws.

ELECT DIRECTORS

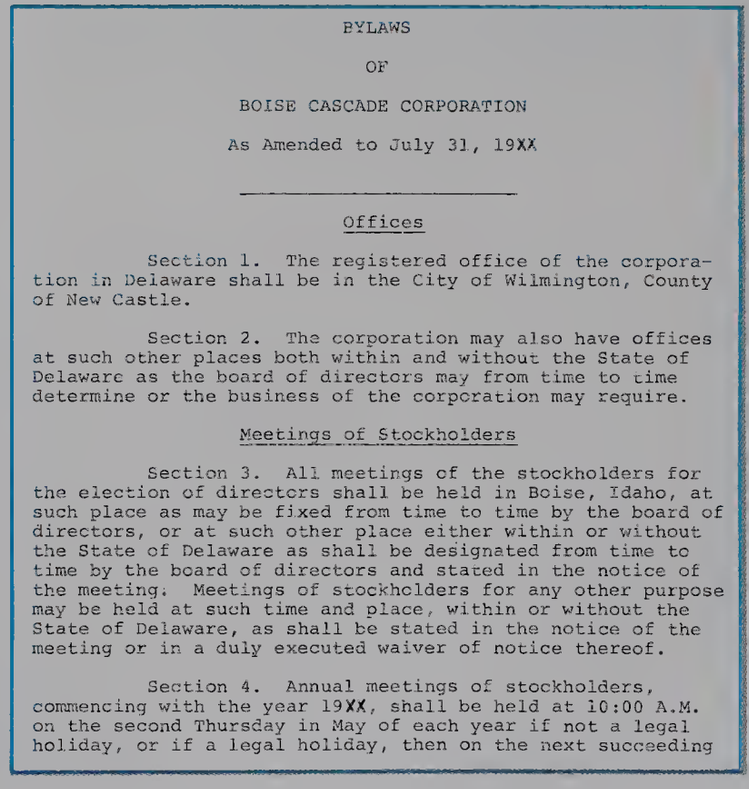
Owners of a company want their investment to be managed wisely. They have provided the money to form the company. In return, they want a secure company and financial rewards. However, few stockholders have the time and, in many cases, the talent, to manage the company. They are generally absentee owners. They do not visit the company nor are they active in its operation.

The stockholders elect individuals to represent their interests. These people are called directors. The group of directors is called the board of directors. The board of directors is the highest level of management in the company. The board of directors is elected to protect the interests of the stockholders. Likewise, the board of directors is like a city council, school board, or state legislature. It is the governing body of the corporation.

The board of directors election process parallels our political system. The stockholders participate in the election. However, there is one major difference. The political system is based on the "one person, one vote" principle. The corporation's elections are based on a "one share, one vote" rule. Stockholders have as many votes as they own shares of stock. Therefore, the greater the ownership, the larger the voice given to each stockholder.

The election of directors is held each year at the annual meeting of the stockholders. The stockholders may attend the meeting to cast their ballots. Those not able to attend may vote by proxy (absentee ballot). In this process, the stockholders submit a card allowing someone else to cast their ballots.

The board of directors is the main governing body of the company, Fig. 17-5. The size of the board



BYLAWS

OF

BOISE CASCADE CORPORATION

As Amended to July 31, 19XX

Offices

Section 1. The registered office of the corporation in Delaware shall be in the City of Wilmington, County of New Castle.

Section 2. The corporation may also have offices at such other places both within and without the State of Delaware as the board of directors may from time to time determine or the business of the corporation may require.

Meetings of Stockholders

Section 3. All meetings of the stockholders for the election of directors shall be held in Boise, Idaho, at such place as may be fixed from time to time by the board of directors, or at such other place either within or without the State of Delaware as shall be designated from time to time by the board of directors and stated in the notice of the meeting. Meetings of stockholders for any other purpose may be held at such time and place, within or without the State of Delaware, as shall be stated in the notice of the meeting or in a duly executed waiver of notice thereof.

Section 4. Annual meetings of stockholders, commencing with the year 19XX, shall be held at 10:00 A.M. on the second Thursday in May of each year if not a legal holiday, or if a legal holiday, then on the next succeeding

Fig. 17-4. The bylaws of a corporation establish general rules for operating an enterprise. (Boise Cascade Corp.)

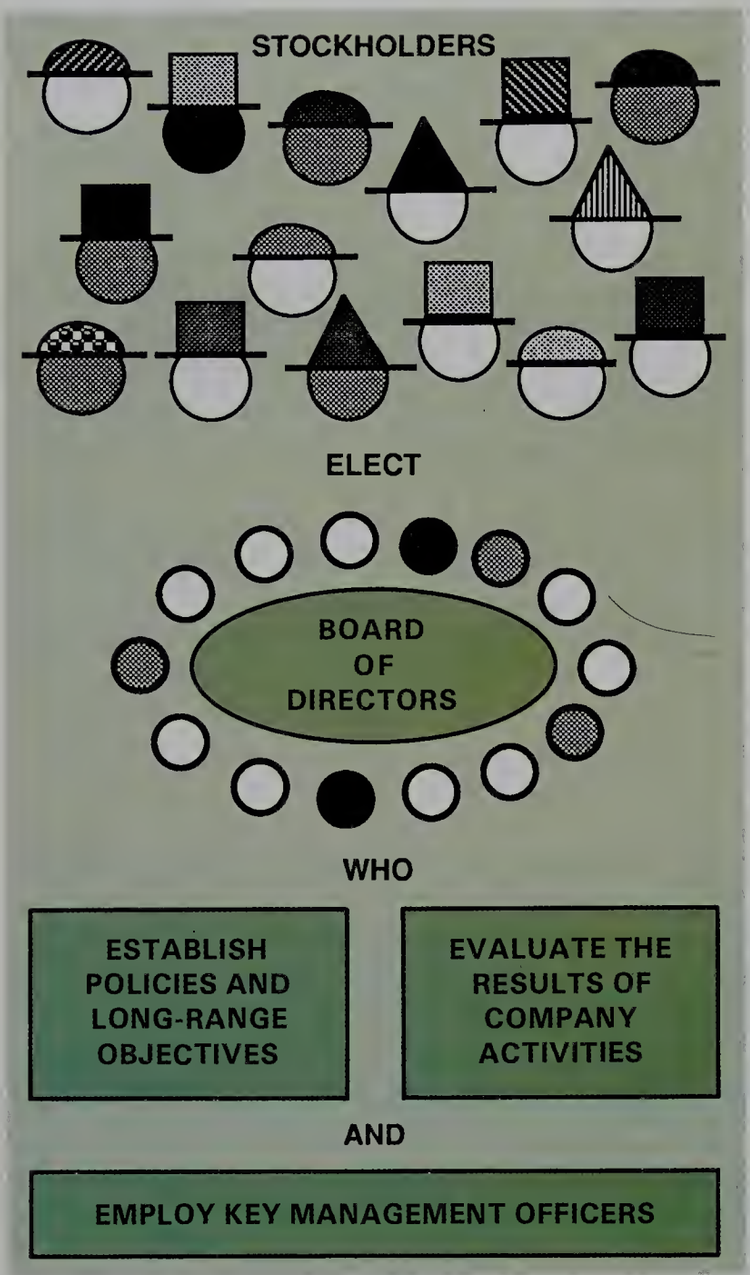


Fig. 17-5. The board of directors plays a key role in managing a company.

varies from company to company. A board may have as few as three members to as many as fifteen or more directors.

A board of directors is often made up of the top managers of the company, the principal owners, and other outside directors. The chief executive officer (CEO), president, chief financial officer, and key vice presidents are often on the board. These individuals are called *inside directors*. They are selected from inside the company.

The remainder of the board is composed of stockholders and outsiders. These are the *outside directors*. They are important to add stability and external control to the company. These directors are generally not major stockholders. They are selected for prestige and often bring specific expertise to the board.

The board of directors meets periodically (monthly or quarterly) to make major policy decisions. They provide vision and general direction for the company. The board does not enter into the active management of the company. This is the responsibility of the full-time managers.

The board is concerned with broad operating procedures, policies, and results. The board meets periodically to form policy and to review company performance.

The activities of the board of directors fall into two major categories. They are summarized as follows:

- Planning activities.
  a. Establishing long-term goals for the company.
  b. Preparing or approving the policies to be followed.
  c. Approving an organizational structure for the company.
  d. Approving major new activities for the company, such as new product lines, plant expansion, etc.
- Controlling activities.
  a. Reviewing production, marketing, financial, and other results.
  b. Recommending changes in procedures to improve company performance.

DEVELOPING A MANAGERIAL STRUCTURE

The board selects the top managers including a *chairman of the board*. This person generally becomes the *chief executive officer (CEO)* of the company. He or she holds the most responsible position in guiding and directing the company.

Beneath the CEO are several levels of management. Establishing the duties and structure for these managers is an important part of forming a company. A sound organizational pattern must be developed. This structure should allow the company to expand in size and number of products. It also must be able to accept and implement change. Organizational structure is a key to growth and long-term corporate life.

Good organization is the key to good management structure. An industrial enterprise may have modern facilities, skilled workers, adequate finances, and abundant raw materials. However, it may be unprofitable. Numerous conditions can lead to unprofitability. A common cause is poor management. This does not mean that some managers are poor and lack ability. It may mean that the company is poorly organized. The managerial structure may keep the company from operating efficiently.

ORGANIZING THE TEAM

The main reason for a managerial structure is to encourage teamwork between and among elements in the company. The goal is to weld the personnel and other resources into an efficient, productive group. Fig. 17-6. *Organization* brings coordination and control over the activities of the company.



Fig. 17-6. Managers help individuals contribute to the overall effort of the company. (American Cast Iron Pipe Co.)

No two companies are organized in the same way. Each develops an organization that suits its goals.

Good organization is based on:

- Information related to the size and purpose of the company.
- The nature of the product to be produced.
- Human resources available.

In developing an organization, consideration must be given to three major management factors, Fig. 17-7. The first is *delegating (dividing and assigning) authority and responsibility*. No one can physically do all the management tasks for even a small manufacturing enterprise. Also, no one can have all the skills and knowledge needed to direct the wide variety of activities within a company.

Therefore, it is necessary to divide the tasks among a number of managers. The larger the company is, the greater the number of divisions there are. Likewise, the larger the company is, the greater the number of managers needed.

Responsibility for the successful operation of a company is divided among various divisions. For instance, a company may have divisions responsible for engineering, marketing, finance, production, public relations, etc.

Therefore, the company management must be viewed from two perspectives, vertical and horizontal. It is divided vertically by levels of authority. The



Fig. 17-7. These factors must be considered when developing a managerial structure.

higher the level, the greater the authority and responsibility assigned to the management position will be.

Each level of management is divided horizontally by function, Fig. 17-8. From this division, a number of positions with similar levels of authority and responsibility result. For example, there is generally a vice-president level on the vertical axis. The horizontal division shows vice-presidents of labor relations, manufacturing, engineering, sales, etc.

The second consideration in organizing a company is *establishing lines of authority*. Whenever a total responsibility is divided among people, lines of authority are needed. These lines tell the employees who answers to whom. It describes the flow of authority and information.

Typically, the lines of authority are communicated on a corporate organization chart, Fig. 17-9. Each person's name and title are listed at the proper location on the chart. These charts are often modified as the company changes its organizations or manager's assignments.

The third consideration for organizing a company is *availability of personnel*. The company's organization often reflects the skill and talents of individual managers. This is particularly true in small manufacturing companies.

Using the above considerations, top management develops an organizational plan. The complete plan includes:

- An organizational chart that includes:
  a. A listing of each department.
  b. An illustration of lines of authority.
  c. An identification of individuals assigned to each job.
- An organization manual that includes:
  a. A listing of each position on the organizational chart.
  b. A statement as to whom each individual is responsible.
  c. A description of the responsibilities for each position.
- A standard practice manual that includes:
  a. A description of the procedures to be used, such as purchasing procedures, accounting practices, quality control procedures, etc.
  b. An identification of the people who will use each procedure.
  c. A description of how to implement and use each procedure.

A successful organizational plan will help workers and managers work together efficiently. It will reduce organizational friction, promote teamwork, and keep operating costs to a minimum.

FINANCING THE ENTERPRISE

Developing a product and getting it to the marketplace takes money. Machines and materials are needed. People must be hired to operate the machines. Customers must be identified. Advertising must be developed and placed. Managers must be employed to coordinate the activities. All of these tasks and hundreds more require money.

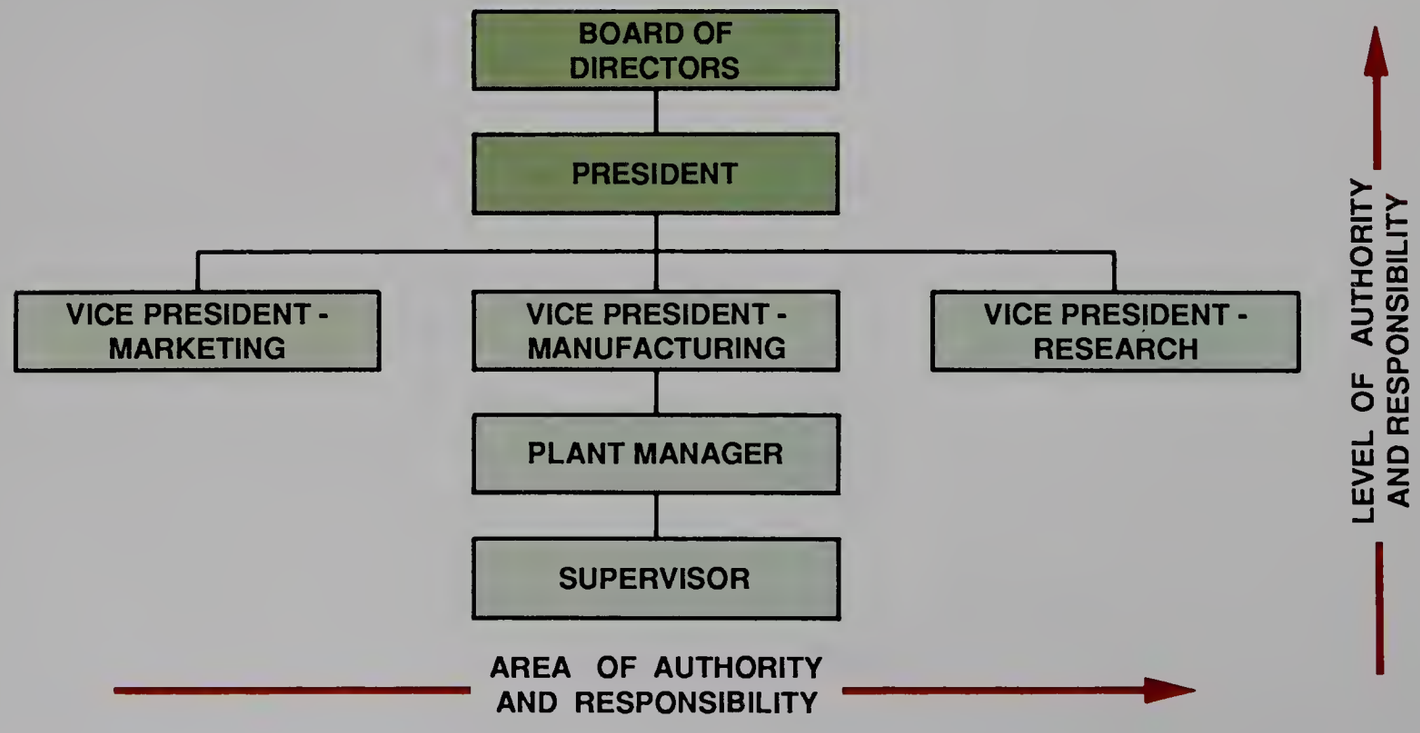


Fig. 17-8. The horizontal and vertical assignment of authority and responsibility is diagramed here.

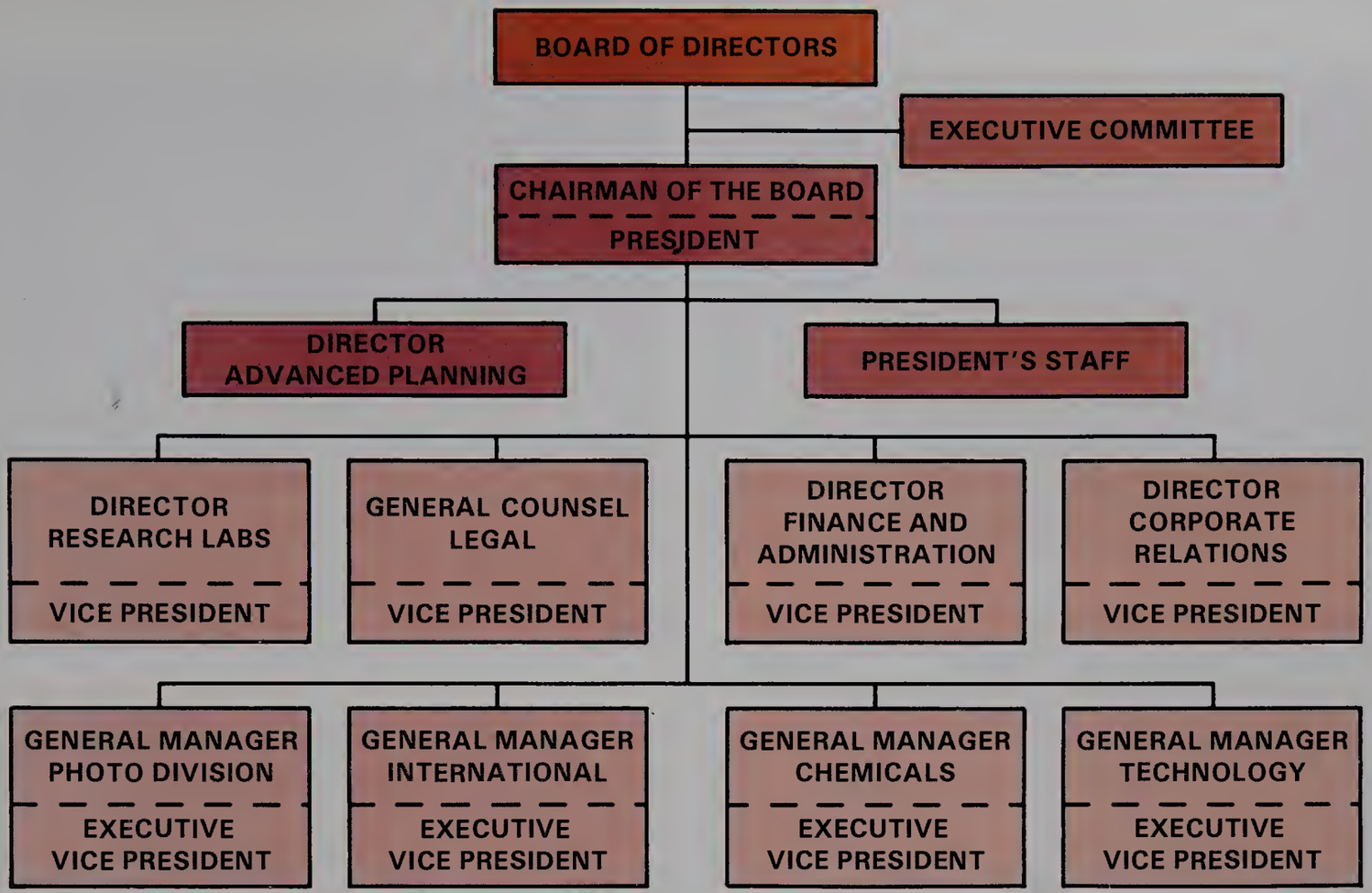


Fig. 17-9. This corporate organization chart was developed from an actual chart from a major photographic supply company.

In their beginning stages, companies need money for four basic reasons, Fig. 17-10. These are:

- Product development.
- Product promotion.
- Working capital to produce an initial number of products.
- Plant and equipment.

The organizers of the company must provide or raise the initial money. The company's financial manager uses loans, equity financing, and trade credit to provide the firm with the lowest cost money available.

The need for money is great, but the sources are often limited. Many financial institutions are not interested in loaning money to new companies. These institutions must protect their clients, policyholders, and depositors. The risk of a new company failing is often too great for some financial institutions to invest their money.

Therefore, a new company often turns to equity financing. They sell shares of ownership to investors, Fig. 17-11. These investors are now part owners or stockholders. Generally, the company's charter and bylaws give stockholders certain rights including:

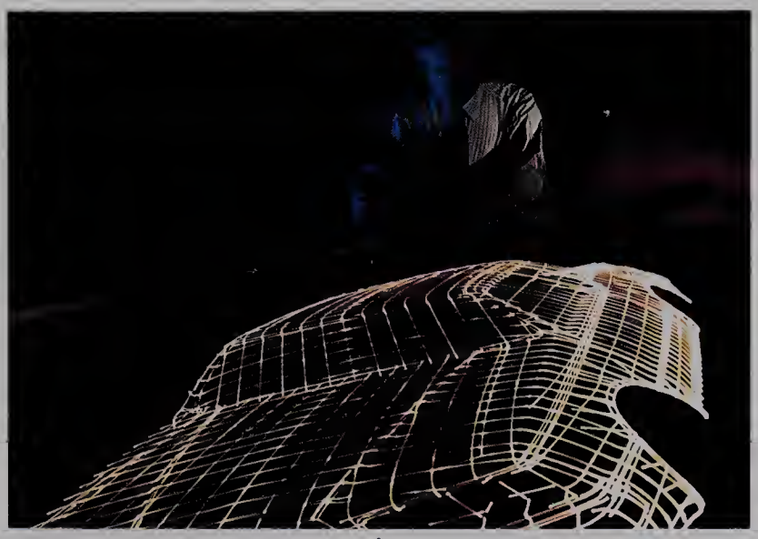
- The right to vote at annual stockholders' meetings.
- The right to sell the stock to another party.
- The right to receive the same dividend as all other stockholders.
- The right to a portion of the company assets if it is liquidated.

Companies have other sources of financing. They may use **trade credit**. This is the credit offered by suppliers. Generally, a company has 30 to 90 days to pay for materials they purchase from their suppliers. Therefore, the company can process these materials before they pay for them. If the product is sold before the bills are due, sales income can be used to pay for the materials.

ESTIMATING INCOME, EXPENSES, AND PROFIT

Money, like all other resources, must be managed. The management of money requires accurate information and recordkeeping. Managers must know how much money is coming in and how much is needed to pay expenses. Also, profit levels for the company and specific products must be calculated or estimated.

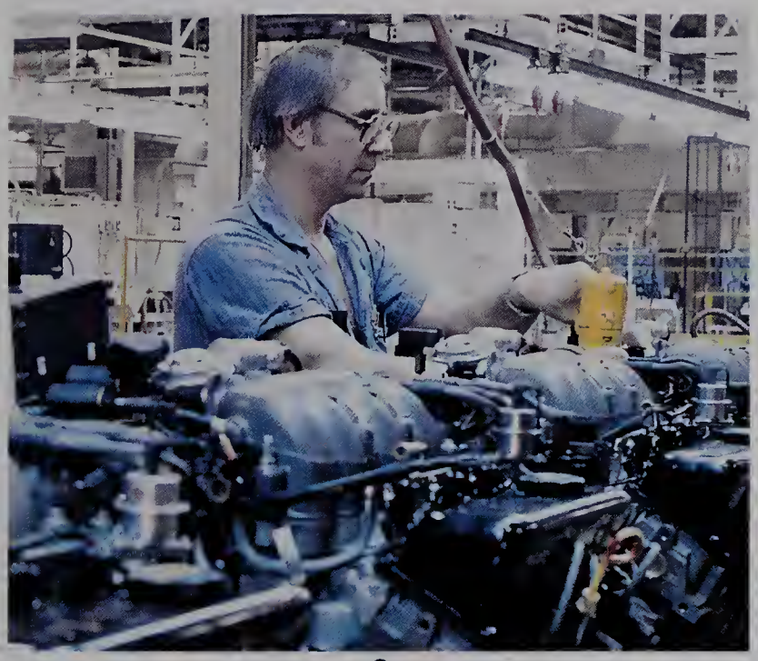
A forecast of the flow of money must be made. Finance managers, like weather forecasters, use data to predict future happenings. A forecast is only as



A



B



C



D

Fig. 17-10. Enterprises need money for: A - Product development. (Motor Vehicle Manufacturers Assoc.) B - Plant and equipment. (Caterpillar Inc.) C - Initial supply of products. (Ford Motor Co.) D - Promoting products to customers. (Graphic Arts Technical Foundation)



Fig. 17-11. This is a typical stock certificate.

good as the information available and the judgment of the forecaster.

A forecast of a company's financial results can be developed using two major tools. These are:

- Budgets.
- Break-even charts.

These tools help managers predict future needs for additional money from loans and stock sales. They are also useful in setting selling prices for products.

BUDGETS

Budgeting systems vary from company to company. (A budget is a plan for the use of a company's money resources.) Smaller companies may use only sales budgets and expense budgets. Larger compa-

nies may use very complex budgeting systems where each activity is expected to prepare a budget.

Five types of budgets are commonly used by manufacturing companies. See Fig. 17-12. These are:

- Sales budgets.
- Production expense budgets.
- General expense budgets.
- Financial budgets.
- Master budgets.

Sales budget

Sales budgets are, for the most part, an estimate of sales for a specific period of time. A budget may cover a month, quarter, or year. Usually, a company's sales are predicted by product and geographic area, Fig. 17-13.

Sales are difficult to predict. A large number of factors can affect the sales of a product. These include new competition, economic conditions, advertising success, negative or positive publicity, and governmental or legal action.

Marketing managers use a combination of several sources of information to develop a sales budget. These sources include:

- Management sources: Advice from financial and marketing personnel is sought. Their insight on market and economic trends provide valuable information.
- Salesperson's opinions: Salespersons are in constant contact with potential customers. They can provide excellent information about customer demand and future needs. They are also fairly

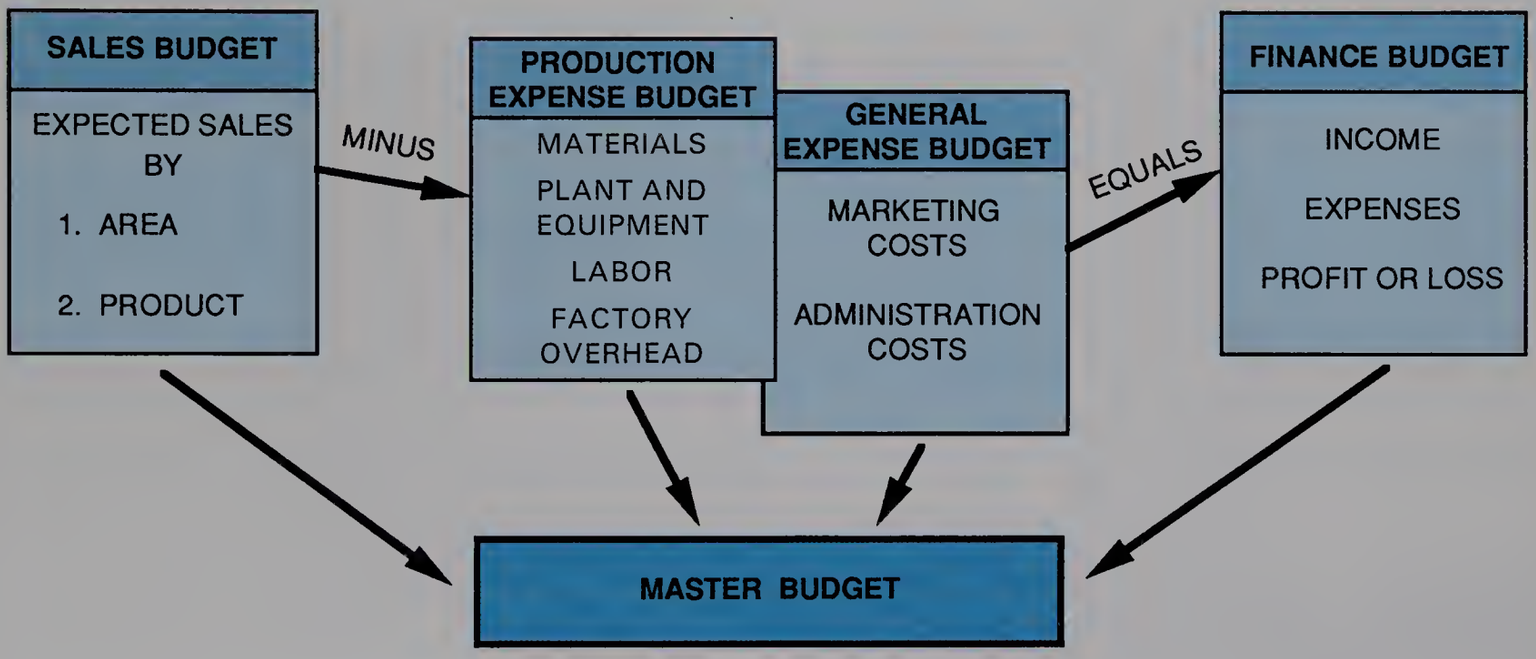


Fig. 17-12. This flow chart shows how a master budget is developed from data on several other budgets.

CDE INCORPORATED SALES BUDGET

	TOTALS		SCHOOL SALES		HOME SALES	
	UNITS	DOLLARS	UNITS	DOLLARS	UNITS	DOLLARS
PRODUCT A @ $2.00						
WEEK 1	15	$ 30.00	9	$ 18.00	6	$ 12.00
2	30	60.00	20	40.00	10	20.00
3	23	46.00	14	28.00	9	18.00
4	22	44.00	13	26.00	9	18.00
TOTAL	90	$180.00	56	$112.00	34	$ 68.00
PRODUCT B @ $1.50						
WEEK 1	20	$ 30.00	9	$ 13.50	11	$ 16.50
2	24	36.00	11	16.50	13	19.50
3	22	33.00	9	13.50	13	19.50
4	18	27.00	8	12.00	10	15.00
TOTAL	84	$126.00	37	$ 55.50	47	$ 70.50

Fig. 17-13. A sales budget estimates the sales for each product by region.

familiar with competitive products and approximate demand for them.

- Past sales information: Company sales records provide data for charting and graphing of product sales. Sales trends can be used to predict future consumer demands.
- Economic conditions: Economic indicators and data are developed by governmental and private agencies. These indicators and data include the consumer price index, unemployment rates, wholesale price index, and the index of leading economic indicators.

Proper evaluation of these data provides a base for developing a sales budget. The predicted sales levels are the base for other company budgets, including production expense budgets.

Production expense budgets

Manufacturing activities must be scheduled to meet sales demands, Fig. 17-14. Production must be scheduled for each week so that a steady flow of products can move from the company to the customers. This schedule is called a **production expense budget**, Fig. 17-15. This particular budget is concerned with production levels rather than costs.

Money is needed to support the production schedule. Materials must be purchased, and people must be paid for their labor. These financial needs are estimated in a production expense budget. The production expense budget generally contains three sub-budgets. Each of these sub-budgets is an important part of the overall production expense budget. The sub-budgets are:

- Material budget.
- Labor budget.
- Factory burden (overhead) budget.

The **materials budget**, Fig. 17-16, lists the quantity and types of materials, parts, and supplies needed to meet production schedules. Material cost estimates can be developed from the data about the materials budget.

The **labor budget**, Fig. 17-17 estimates the amount of labor required to meet the production schedule. A labor budget can serve two functions. First, it is a forecast that allows the employment department to recruit, select, and train personnel. Second, it provides a basis for forecasting labor costs for each product. This information is a vital part of a production expense budget.

The **factory burden (overhead) budget** provides a basis for assigning overhead costs to products. Each product must contribute to paying the factory costs such as utility bills and maintenance.

Material, labor, and overhead costs are the actual costs of producing the product. These costs are used to develop a production expense budget.

General expense budget

Not all expenses are directly related to producing products. Companies must have general managers. Products must be marketed. Personnel must be hired and trained. These and similar costs are called general expenses. They are estimated on **general expense budgets**. Two major general expense budgets are:

- **Marketing budgets:** These are estimates of costs associated with promoting, selling, and distributing the product.



Fig. 17-14. Production schedules for this furniture factory were developed from the sales budget and directly affect the production expense budget.

CDE INCORPORATED PRODUCTION SCHEDULE (BUDGET)

WEEK	SALES (1) FORECAST	SCHEDULED (2) INVENTORY	PRODUCTION (3) REQUIRED
PRODUCT A			
I (APRIL 1-5)	15	20	35
II (APRIL 8-12)	30	20	30
III (APRIL 15-19)	23	10	13
IV (APRIL 22-26)	22	0	12
PRODUCT B			
I (APRIL 1-5)	20	20	40
II (APRIL 8-12)	24	20	24
III (APRIL 15-19)	22	10	12
IV (APRIL 22-26)	18	0	8

Fig. 17-15. The production budget estimates levels of production required to meet the sales forecast (budget).

MATERIAL BUDGET

PRODUCT: _____ **MONTH:** _____

ITEM	QUANTITY NEEDED				
	WEEK 1	WEEK 2	WEEK 3	WEEK 4	TOTAL

Fig. 17-16. This material budget form, when completed, will estimate the materials needed to support the production schedule.



CDE INCORPORATED LABOR BUDGET

PRODUCT A					
WEEK I APRIL 1-5	**UNITS TO BE PRODUCED**	**TIME PER UNIT**	**TOTAL TIME**	**COST PER TIME UNIT**	**TOTAL COST**
ROUGHING DEPT.	55	6 MIN.	330 MIN.	$4.00/HOUR	$22.00
MACHINING DEPT.	50	5 MIN.	250 MIN.	5.00/HOUR	20.80
ASSEMBLY DEPT.	45	5 MIN.	225 MIN.	5.00/HOUR	18.80
FINISHING DEPT.	40	3 MIN.	120 MIN.	4.00/HOUR	8.00
PACKAGING DEPT.	35	1 MIN.	35 MIN.	4.00/HOUR	2.40
PRODUCT B					
ROUGHING DEPT.	60	4 MIN.	240 MIN.	$4.00/HOUR	$16.00
MACHINING DEPT.	55	5 MIN.	275 MIN.	5.00/HOUR	22.90
ASSEMBLY DEPT.	50	4 MIN.	200 MIN.	5.00/HOUR	16.60
FINISHING DEPT.	45	2 MIN.	90 MIN.	4.00/HOUR	6.00
PACKAGING DEPT.	40	1 MIN.	40 MIN.	4.00/HOUR	2.60

Fig. 17-17. The estimated labor needed to meet the production schedule is provided by a labor budget. (Zero Corp.)

- **Administrative budgets:** These are estimates of costs involved in research and development, financial affairs, and industrial relations activities.

Most companies find that the general expenses are a fairly constant percentage of production costs. Therefore, they simply assign a overhead charge to each product.

Financial budgets

The income and expenses of a company seldom rise and fall together. Early in new product development, expenses will exceed income. Likewise, seasonal products require an inventory build-up prior to the large selling season. Therefore, during a year, a company may need outside money to finance operations. This money can be paid back later as sales increase.

Financial budgets are prepared to predict income and expenses for specific periods of time. This budget helps the financial officers to determine needs for outside money. The budget also allows the company to schedule the payment of loans.

Master budget

Specific budgets provide considerable detail about selected portions of the company's operations. For example, production expense budgets will predict material needs and costs. However, top managers need "the big picture." They need to see predictions for the financial results of all the company's operations. They need to see a summary budget. This budget is called a **master budget.** When approved, the master budget becomes the financial plan for the budget period.

Through the budgeting process, managers are able to estimate:

- Sales for each product.
- Production levels needed to meet the sales forecasts.
- Costs for manufacturing each product.
- Cost of marketing each product.
- Administrative costs.
- Material and personnel needs and costs.
- Financial needs.
- Company and product profit levels.

BREAK-EVEN CHARTS

Break-even charts are the second major tool used to predict company success. Break-even is the point at which sales income from a product meets all direct and indirect costs assigned to it. At this point, the

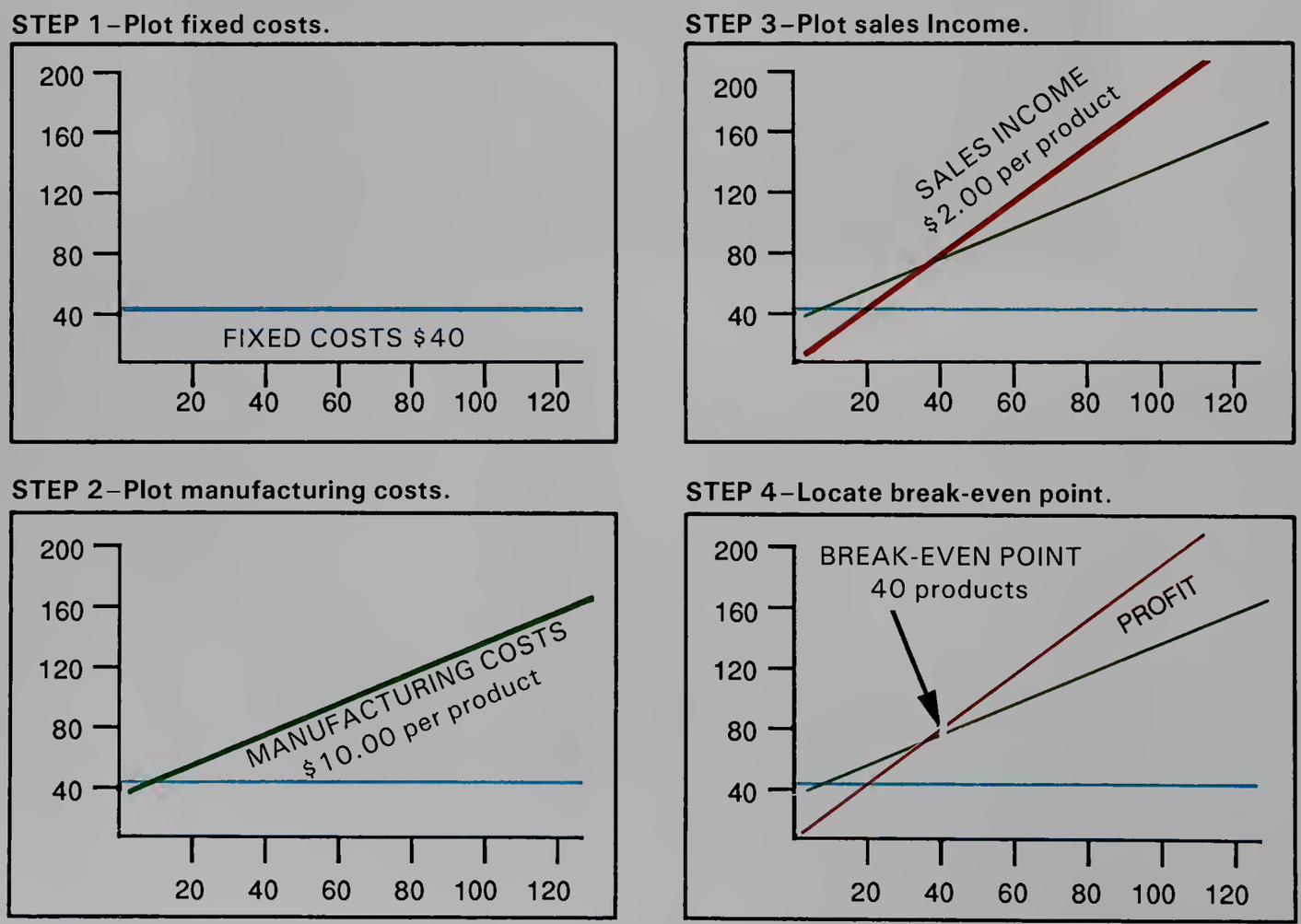


Fig. 17-18. A break-even chart is prepared using information from company budgets.

company will neither make or lose money. Additional product sales beyond break-even will result in a *profit*. Failing to meet the break-even point will cause the company to suffer a loss.

A break-even chart graphically shows the relationship between:

- Volume of production and sales.
- Income and expenses.

Income increases as sales increase. However, expenses increase as production levels are increased to meet the sales demand. The task of management is to see that sales income increases faster than production expenses. Financial managers use a break-even chart to view this relationship. They produce the chart by applying the following data from company budgets:

- **Fixed costs:** These costs remain constant as production levels change. They are general expenses and factory overhead.
- **Manufacturing (variable) costs:** These are the costs that vary with production levels. They include material and labor costs. Manufacturing costs are calculated for each product using the formula:

$$\text{Cost per product} = \frac{\text{material cost} + \text{labor cost}}{\text{number of products budgeted}}$$

- **Sales income:** This is the estimated income derived from each product sale.

When this data is plotted, the expense and sales income lines should cross, Fig. 17-18. This is the break-even point. The area between these two lines indicates a profit or a loss. The area to the left of the break-even point is the loss, and the area to the right is the profit.

The break-even chart can be used to predict the affects of company actions on profit. Reducing the selling price of a product will generally increase sales and income, but will the additional income result in more profit? This is not always true. The break-even chart becomes a valuable tool in determining selling price, predicting profit margins, and analyzing the effect of increasing costs or selling prices.

SUMMARY

Companies are legal entities. They are formed by people to provide a product or service. Successful companies have an effective managerial organization and realistic financial plans. They assign varying levels of authority and responsibility to all employees. Successful companies also use budgets and break-even charts to predict the financial success for the company.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

administrative budgets
articles of incorporation
break-even chart
bylaws
charter
factory burden (overhead) budget
financial budget
fixed costs
general expense budgets
labor budget
manufacturing (variable) costs
marketing budgets
master budget
materials budget
production expense budget
sales budget
sales income
trade credit

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the four major tasks faced by all beginning enterprises.
2. The board of directors of a company is often made up of:
   a. The top management of the company.
   b. The principal owners.
   c. Outside people.
   d. All of the above.
3. Name the three major management factors that must be given consideration when developing an organization.
4. List four reasons companies need money in their beginning stages.
5. True or False? Sales budgets are prepared to predict income and expenses for specific periods of time.
6. True or False? When approved, the master budget becomes the financial plan for a company's budget period.
7. The _____-_____ chart graphically shows the relationship between volume of production and sales and the relationship between income and expenses.

8. The task of management is to see that:
   a. Sales income decreases as production expenses increase.
   b. Sales income increases faster than production expenses.
   c. The company breaks even.
   d. None of the above.

APPLYING YOUR KNOWLEDGE

1. Using a form like the one in 17-A, suggest two names, a logo, and two slogans for a student company.
   a. Normally, this will be an activity involving groups of students or the whole class. Follow your instructor's directions.
   b. Suggestion: Work on the company names first. A company logo should bear some relationship to the company name.
   c. Think about an appropriate logo. It can be a letter, group of letters, or signs that stand for whole words. Think of some well-known companies and how their logos are instantly recognizable.
   d. Sketch the logo on scrap paper until you have the design you want. Then place it on the form.
   e. Suggest two slogans. This is a brief, attention-getting phrase or sentence used in advertising. Again, write down different slogans on scrap paper and select the ones you like best. Place them on the form.
2. Visit a stockbroker to find out how companies are financed. Give a two-minute report to the class about the information you obtained.
3. Develop personal weekly and monthly budgets covering the next three months. Include income, expenses, and savings.

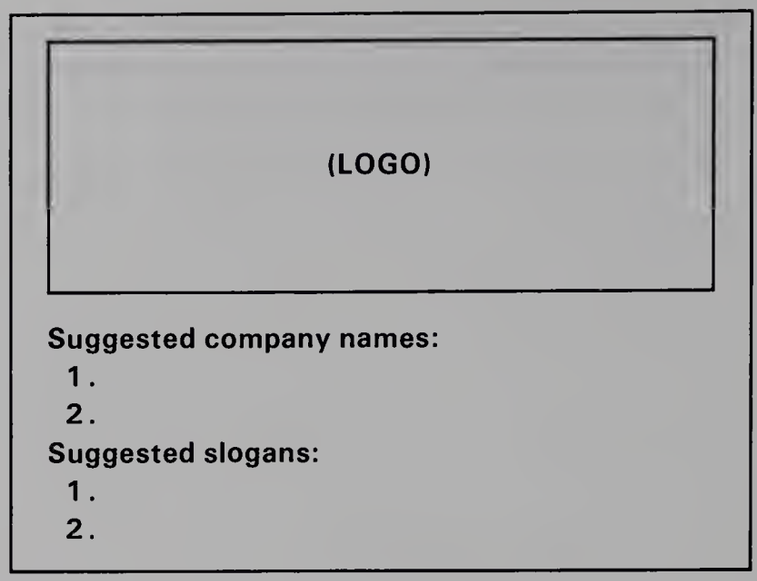


Fig. 17-A. Make a form similar to this one on which to prepare your logo, company names, and slogans.

18
CHAPTER

DEVELOPING A PRODUCT

After studying this chapter, you will be able to:
- *Determine how companies design products to meet customer needs and wants.*
- *Explain how product ideas are developed.*
- *Describe how product ideas are screened.*
- *List the three elements necessary in designing and developing a product.*
- *Explain how product characteristics are specified.*
- *Review the total development of a product.*

All companies face a common problem: finding the right product to introduce into the marketplace, Fig. 18-1. This problem is faced by new companies as they select their first products. Maturing companies must also develop new products to enlarge their operations or replace "dying" products.

All manufacturing companies strive for a winning product. A winner is a product people want and that will earn the company a profit.

Developing new products is a practical, managed series of activities. The process includes the three functions of research and development presented in Chapter 15:
- Research.
- Development.
- Product engineering.

Research and development functions become a reality as six major product design steps are completed. The steps, as shown in Fig. 18-2, are:
1. Determining product needs.
2. Finding product ideas.
3. Screening product ideas.
4. Designing and developing the product.
5. Specifying product characteristics.
6. Obtaining managerial approval for developed products.

DETERMINING PRODUCT NEEDS

Successful companies design products to meet customer needs and wants. They approach this challenge in one of two ways: a production approach or a market approach.



Fig. 18-1. Successful companies generate a continuing flow of new products. (Hon Industries)

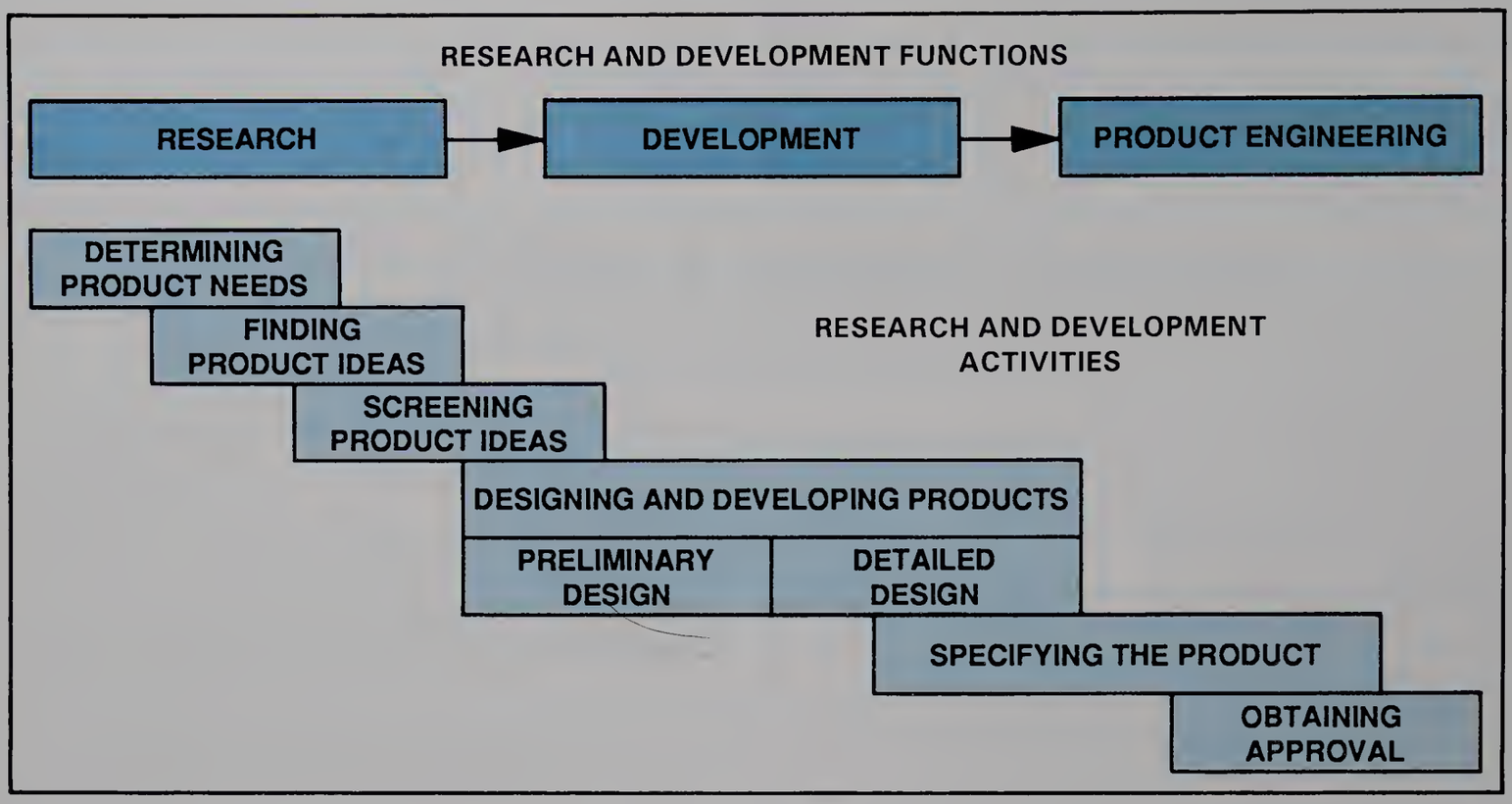


Fig. 18-2. Companies complete six major tasks through their three research and development functions.

In the **production approach**, companies focus on producing products that fit their companies. They match the product to the equipment they have, the skill of their workers, and their marketing systems. Once the product is designed, the company uses advertising to build a demand for the product. The company wants the customer to react to the product. Most high-volume, low-cost consumer products, like toothpaste, laundry detergents, and clothing, are developed through this approach.

The **market approach** focuses on customers. Their product desires are carefully studied. Then a new or improved product is designed to meet customers' expectations. The company reacts to customers. Most industrial products are developed through the market approach. For example, machines and equipment are generally designed to meet customers' applications, Fig. 18-3.

Product design activities must be based on information. This information may be gathered from a number of sources. One source is *competitors*. Their products can be carefully studied and tested. This will provide information about product development trends and new technical innovations. The information can be used later as salespersons compare the new product to the competition.

Customers, like the one shown in Fig. 18-4, are another source of information. They may be asked to react to product designs, give data about themselves, or describe their buying habits. This activity, as you learned in Chapter 15, is called *market research*. It provides three major types of information:

- **Product information:** This describes customer reactions to existing products and their desires for new products. Information about product function, styling, operation, and performance is often gathered.
- **Market information:** This identifies the segment of the market that is most likely to purchase the



Fig. 18-3. These tracks for the U.S. Army's M-1 tank were developed using a market approach. They were designed to meet the customer's needs. (Goodyear Tire and Rubber Co.)

product. This data includes information about the age, sex, income level, occupation, geographic location, and shopping habits of the "average" customer for the product.



Fig. 18-4. Customers are a valuable source of information about present products and for future product development activities. (Federal Industries)

- **Marketing system information:** This identifies the effectiveness of advertising, sales approaches, distribution channels, and packaging. This data helps in designing a marketing plan for the new product.

Market research may take one of several forms. It may be conducted through personal contact. The customer may be selected and asked to respond to a number of questions. A questionnaire may be administered in person or mailed to the potential customer, Fig. 18-5. Sometimes, a new owner of a product may be asked a series of questions. Often, a questionnaire is attached to a guarantee card. Customers are asked to complete the questionnaire and return it.

Historical records can also reveal important information. Sales trends for existing products can be used to predict the success of a new product. This information can also identify products that need to be redeveloped or dropped from production.

Another market research technique is the **test market**. This technique identifies an area that represents the "typical" national population. The product is introduced into the area with appropriate advertising and sales support. Customer acceptance of the product is used to forecast national trends and sales levels. Products advertised as "available in a limited area" may be in a test market.



Fig. 18-5. Potential users of a product may be asked to react to the design and function of a product. (Ford Motor Co.)

FINDING PRODUCT IDEAS

Product ideas are not a chance happening. They result from the serious efforts of individuals or groups. Henry Ford, Cyrus McCormick, and Eli Whitney worked as individuals on product ideas. Ford developed a low-cost, mass-produced automobile. Whitney developed the cotton gin and refined the concept of interchangeable parts for musket manufacture. McCormick revolutionized farming with the reaper.

Thomas Edison and Steven Jobs, by contrast, worked with a dedicated group of people. Edison gathered a number of scientists at his Menlo Park, New Jersey laboratory. There, he operated an invention factory that was responsible for hundreds of products. The list included the phonograph, motion picture camera, and the incandescent lamp. He and his staff were responsible for over 1000 patents.

Jobs led a creative group that developed the MacIntosh computer. Their efforts ushered in a new era for the micro-computer revolution. The MacIntosh provided a user friendly (easy-to-use) computer that did not require computer language skills.

The day of the private inventor has probably passed. Certainly some of these people exist and develop new products. However, their impact is less dramatic than it was a century ago.

The private inventor has, for the most part, been replaced by company-organized product development activities, Fig. 18-6. This organized activity is responsible for finding new products to keep the company profitable and competitive. This task generally includes:

- Identifying the type of product the company can successfully manufacture and market. This activity often results in a product profile.
- Generating product ideas that fit the product profile.

PRODUCT PROFILE

An early task for a product design team is to carefully develop a **product profile**. The product profile lists the general requirements that a new product must meet. A number of elements must be included in a product profile, Fig. 18-7. These may be grouped under five categories:

- The market.
- The product.
- Price range and profit potential.
- Sales volume.
- Finances required.

A description of the present or desired customer is included in the **market profile**. A great deal of information is gathered about the type of customer the company serves or wants to reach. The age, sex, location, income, occupation, and buying habits of potential customers are described.

The product description will suggest the type of product that can be produced by the company. It will consider the material, capital (equipment), and human resources the company possesses or can obtain.

The estimated selling price limits the type of products considered. Enterprises can control their investments in new products by controlling their size and complexity. Large, complex products usually have a higher selling price, but they require large initial investments. Small companies may have limited financial resources and, therefore, must control the size of product development projects. On the other hand,



Fig. 18-6. This technician is helping to develop a ceramic material that may someday be used for wear resistant parts in automobile engines. (Aluminum Co. of America)

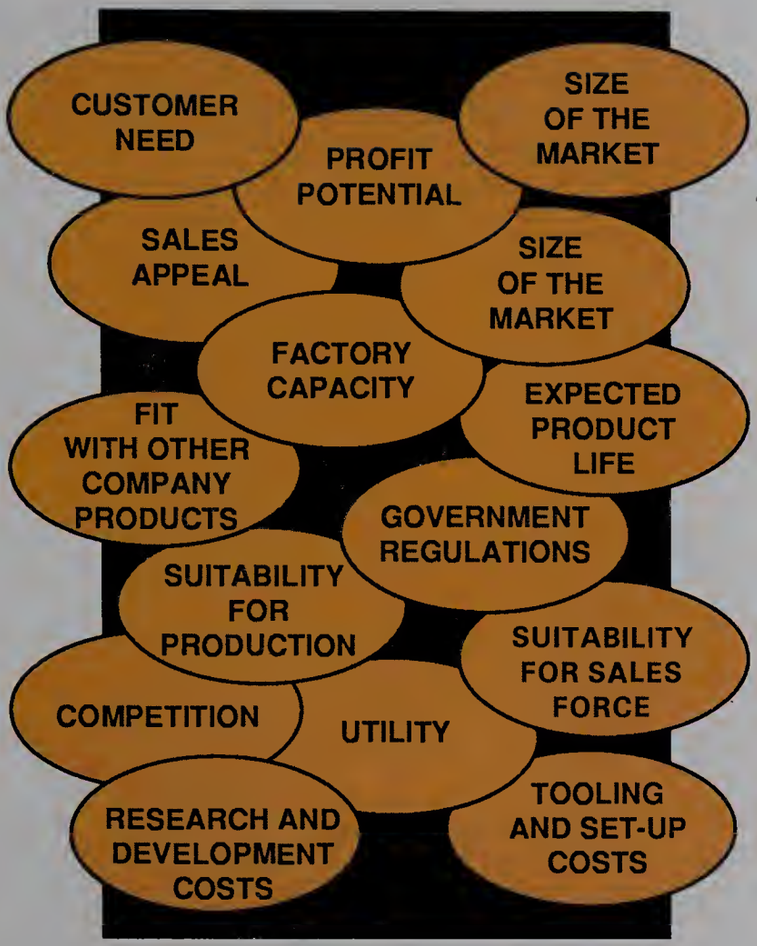


Fig. 18-7. The product profile defines the type of product a company will consider.

larger companies may not want to pursue products that have limited markets and profit potentials. For larger companies, a certain level of projected income is necessary before a product is attractive. Generally, large companies will not consider low-priced, low-volume products.

Many companies put minimum limits on product volume. These limits may be expressed in sales income, return on investment (ROI), or return on assets (ROA). For all companies, a minimum sales volume is needed to make a product worth developing.

The last profile factor is the financial resources required to bring the product to the market. This figure includes the cost of developing the product, engineering the production facility, obtaining initial human and material resources, manufacturing the product, and marketing it.

SEEKING PRODUCT IDEAS

The completed product profile, in short, tells company managers:

- The type of product in which the company is interested.
- The production capabilities the company possesses.
- The product price range and sales volume that is acceptable.
- The maximum financial resources (money) the company will devote to a new product.

This information helps focus the efforts of **product developers**. These people are charged with seeking product ideas that are compatible with the company. These ideas may be developed by product development personnel within the company, or they may come from outside the company. In some cases, companies purchase product ideas, or they may license a product from an individual or another company. Sometimes a company will buy another enterprise to obtain new product lines. In still other cases, the company may obtain permission to produce products developed by governmental agencies, universities, and private research laboratories. These and other sources of product ideas are listed in Fig. 18-8.

SCREENING PRODUCT IDEAS

The product profile is the first screening tool in seeking product ideas. It sets limits and gives direction to the product development activity. It is possible, however, for many product ideas to fit within the limits established by the profile.

Not all ideas that fit the profile will find success in the market place. In fact, research shows that for every 100 initial product ideas, only three reach the marketplace. Of these three products, only one is profitable.

The goal is to improve this "batting average" by increasing the success rate for new product ideas. Therefore, it is critical that only the best product ideas are selected for refining and developing. The evaluation of product ideas should be made by key executives or a new products committee. This group should include personnel from many areas of the company including manufacturing, marketing, research, and financial affairs.

Like all management decisions, product idea selection should be based on facts. Wise management decisions can only be made by knowledgeable people. The managers must have proper information to function successfully.

Typically, managers need three types of information to screen product ideas. These are:

- Engineering data.
- Marketing data.
- Financial data.

ENGINEERING DATA

Engineering data includes information related to the product and how it is manufactured. Product appearance, function, and operation are important considerations. Usually, sketches are produced to communicate this information.

Two types of sketches are used to develop initial product ideas. The designer develops **rough sketches** that move design ideas from his or her mind onto paper. These sketches form a library of ideas that can be integrated into a specific product idea. This more complete product idea takes form in **refined sketches**, Fig. 18-9. Here, the designer pulls together a number of design ideas and incorporates them into one or more product sketches.

These refined sketches are used to communicate with the product evaluation team. They show how the product will look and work, Fig. 18-10. The sketches may present ideas for the total product or for components of it.

Other engineering data list product development and engineering tasks and the expenses associated with them. These expense estimates include design and development, engineering, product testing, and tooling costs.

How some manufacturers located ideas for new products

Company	New product	Source of idea
Meat packer	Onion soup	Executive
" "	Canned chicken product	Sales
Manufacturer of industrial equipment.	Steam-producing unit	Advertised sale of manufacturing rights.
Tinplate cnnverter	Breadbox	Market research agency assigned to study new product possibilities.
Electric appliance manufacturer.	Foot warmer	Customer inquiries.
Manufacturer of golf equipment.	Golf bag "toter"	President of company.
Manufacturer of service equipment for garages.	Hoist for garage	Garage mechanic contacted during survey of product users.
Chemical company	Deodorant for garbage	Advertising agency, which learned of local use.
Chemical and film company.	Detergent	Laboratory.
Die casting company	Line of dejuicers	Company executives.
Manufacturer of plastic product.	Film viewing device	Inventor.
Manufacturer of kitchen utensils and gadgets.	Kitchen gadget	Register of patents available for licensing or sale. (U. S. Patent Office.)
Chemical products company.	Insecticide	List of Government-owned patents available for licensing.
Manufacturer of office equipment and machinery.	Index device, envelope opening device, pencil gripper.	Office managers. Also jobber and wholesaler catalogs.
Canner	Apple juice	Food broker.
Appliance manufacturer	Electric bottle-warmer	Customers.
Film company	Film	Engineer.
Landscape supply and equipment company.	Fiber glass blanket to place around tree to keep down weeds and retain moisture in soil.	Register of patents available for licensing or sale.
Container manufacturer	Re-use container	President of company (noticed waste of materials)
Plumbing equipment and supply manufacturer.	New washer	Sales report.
Manufacturer of hardware.	Bedroom door knockers. Also miniature jewelry door knockers.	Executive in considering idea of reducing size of regular door knockers.
Pottery manufacturer	New vase	Museum exhibit.
Plastic products company.	Plastic shield for wall light switch.	Inventor.
" "	Film slide viewer	List of needed inventions published by a bank.
Chemicals manufacturer.	New type detergent for automatic washing machine.	Market observation showed need for sudsless detergent.
Engineering consultant	New type air regulator valve.	Observation of industry need not previously satisfied.
Legal firm	Canned fresh water for storage in lifeboats.	Ship's captain asked lawyer specializing in marine claims to try canning drinking water. Idea succeeded and new firm was started. Some canning companies previously considered such storage in tin cans impossible.
Marine engineering	Toy	Accidental dropping of coiled spring at head of stairs. Engineer's children enjoyed watching it "walk down."
Machine tool builder	Machine for textile industry.	Examination of machinery needs of noncustomer industries. The company knew that the textile industry didn't use lathes but reasoned, it might use machines which could be produced by a machine-tools manufacturer. After a thorough study of the textile industry the company selected 4 textile machines for manufacture.

Fig. 18-8. This is a list of some sources of new product ideas. (Small Business Administration)

MARKETING DATA

Marketing data presented to the product review team includes information on potential customers. The data predicts who the customers are, where they live, their buying habits, the number of products they will buy, how they might use the product, etc.

Also included in the market data is a review of the competitive environment. Competing and substitute products are reviewed and discussed. The strengths and weaknesses of the competitors are noted. Information about the competition indicates:

- The percentage of the market held by each competing product.



Fig. 18-9. This designer is developing refined sketches for a new toy. (Ohio Art Co.)



Fig. 18-10. This product evaluation team is reviewing rough sketches (left), refined sketches (right), and renderings (center). These provide one type of engineering data. (Western Electric Co.)

- The level of customer loyalty to specific products and manufacturers.
- Competitors' new product development activities.
- Financial, production, and marketing strengths of each competing company.

Another type of marketing information reviews the company's own marketing strengths. It describes how the product falls within the present marketing effort. Also, the new product's role within present company advertising, sales, and distribution systems is presented.

FINANCIAL DATA

Financial data provides a view of a product's monetary impact on the company. The data includes preliminary estimates of the manufacturing costs, selling price, and expected profit.

Obviously, estimates in the early stages of product development are tentative. They are reviewed and revised at several stages. As the product moves through development and engineering, new information makes more accurate predictions possible.

The engineering, marketing, and financial data is usually presented at formal product review meetings, Fig. 18-11. These meetings are used to identify good product ideas and development projects. The product ideas that show limited promise will be stopped or put on hold.



Fig. 18-11. Product ideas are presented at a number of stages at product review sessions. The product can receive approval for continued development, direction for modifications, or be stopped at any point. (Motor Vehicle Manufacturers Assoc.)

DESIGNING AND DEVELOPING PRODUCTS

A product idea must progress from the designers' sketches into reality, Fig. 18-12. The idea becomes a product that customers need or want. The product review team approves initial product design directions presented by designers. The tentative markets are targeted. Financial resource needs are approved.

The product is now ready to be designed and developed. The product will pass through several steps as it moves from sketches and descriptions into a physical item.

Product designs must be developed with three elements in mind. These, as shown in Fig. 18-13, are:

- Design for function.
- Design for manufacture.
- Design for selling.

DESIGNING FOR FUNCTION

All design activities should lead to a functional product. Any new product should do the job it was designed to do. It should work well under the conditions the customer will use it. For example, windshield wipers should work well when it is drizzling, pouring down rain, sleeting, or snowing. They should work during warm or cold weather, when the car is in stop-and-go traffic, or at freeway speeds.

Each product must be designed to operate under all expected uses. The designer must answer the question, "Will the product do what it is designed to do?"

DESIGNING FOR MANUFACTURE

Products should provide value at a reasonable price. A challenge for manufacturing is to manufacture products with a minimum use of resources. Excess parts, unnecessary design frills, and complex operations should be reduced. In short, the product should be produced with the greatest possible ease.

The designer should constantly strive to reduce the amount of material used by simplifying the design and reducing waste and scrap. The number of different materials and parts should be reduced whenever possible. Parts and fasteners should be standardized. Readily available materials, parts, and hardware should be used.

Designers often try to combine small parts into single, larger parts. Whenever possible, parts should be used for several products, thereby reducing development and inventory costs.

All products should be designed for easy assembly. Parts should align themselves whenever possible to reduce assembly tooling costs. The least costly and quickest functional assembly systems should be used.

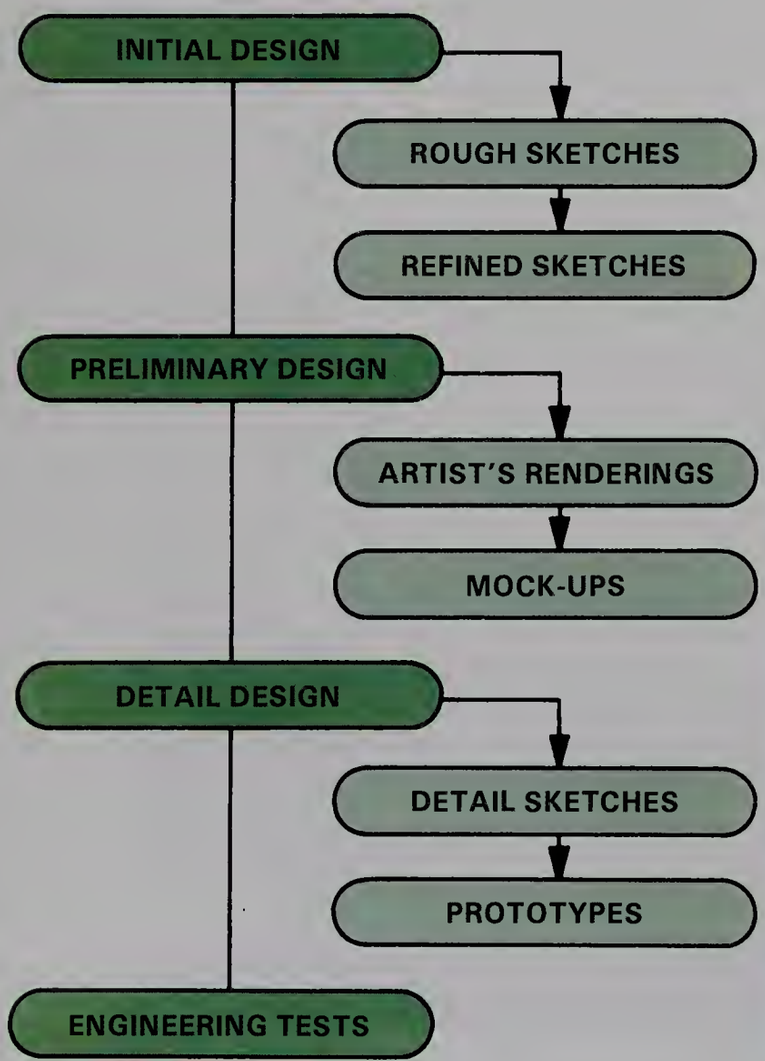


Fig. 18-12. This diagram shows the steps in product design as a part of product development.

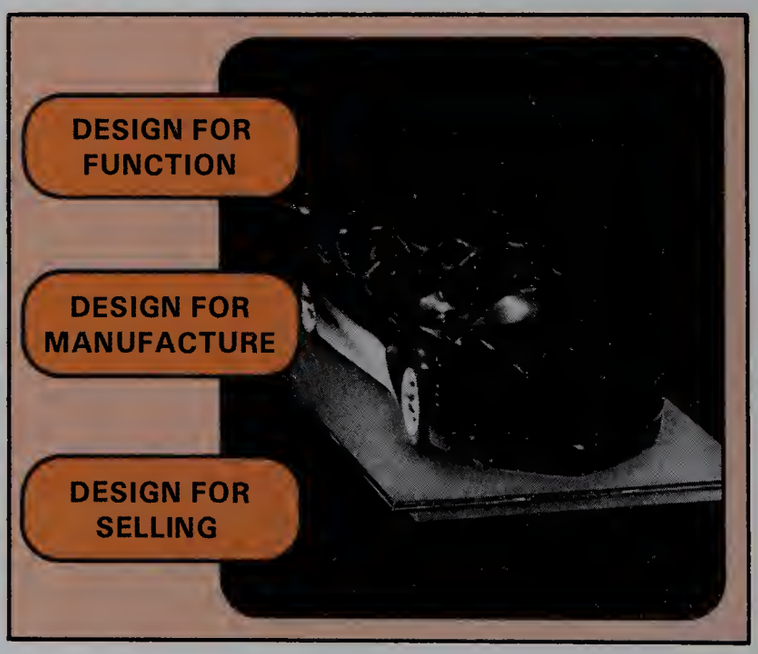


Fig. 18-13. Designers must consider function, manufacture, and selling as they design a new product.

DESIGNING FOR SELLING

In order for a company to be successful, products must sell. Product sales, to a large extent, are related to the design.

Generally, a customer is first attracted to a product by its appearance. The product must be attractive to have customer appeal. Many principles can be applied to creating a pleasing design. Three key guides are:

- Keep the design simple. Avoid unnecessary curves, frills, and other design elements.
- Communicate function. The customer should know what the product is from its appearance. It is not a good idea to use a product disguise such as dog bookends or a teapot clock. A product, through its design, should tell the customer, "I am a bookend," or "I am a clock."
- Deliver value. The customer must see the product as being worth the selling price.

PRELIMINARY DESIGN

The movement of a product from a designer's ideas in rough sketch form to a product requires three steps. These steps start with the approved ideas that were based on initial engineering, marketing, and financial data. They are:

1. Preliminary design activities.
2. Detail design work.
3. Engineering testing.



Fig. 18-14. These designers are reviewing a rendering for a futuristic automobile. (Motor Vehicle Manufacturers Assoc.)

Preliminary design activities

Preliminary design activities are activities based on the ideation process that was shown on rough and refined product idea sketches. This step starts where the refined sketches ended. It includes preparing artist's renderings of the various styling features, Fig. 18-14. The *rendering* is a shaded or colored pictorial sketch. It is prepared to give an overall impression of the product or component being designed. The rendering allows managers and design personnel to visualize the appearance of the final product.

After the rendering is approved, a mock-up of the product is often built, Fig. 18-15. A mock-up is an appearance model. It shows the general size and styling features of the product, but not its function. The mock-up does not, generally, include working parts or components.

Mock-ups are made of easily worked materials such as clay, paperboard, balsa wood, and acrylic plastic, Fig. 18-16. The result is the first three-dimensional view of the designer's product idea.

During the preliminary design phase, engineers are also concerned with designing parts and systems. They may start designing electrical and mechanical systems needed for the product.

Detail design work

After the preliminary designs are complete, **detail design** work begins. Detail design gives the product its final appearance and functional characteristics. These activities include:

- Preparing sketches of details.
- Producing prototypes.

During the preliminary design phase, the overall appearance of the product was developed. However, the product is composed of a number of specific parts and features. These elements provide the detail for the product, and each detail must be designed.

Every part must be carefully designed to fit into the overall appearance and function of the product. Detail design personnel are responsible for this task, Fig. 18-17. They divide the product into major components and develop each of them. They produce dimensioned (detailed) sketches for each part and assembly.

These sketches are used to produce a prototype or working model of the product. This model, as shown

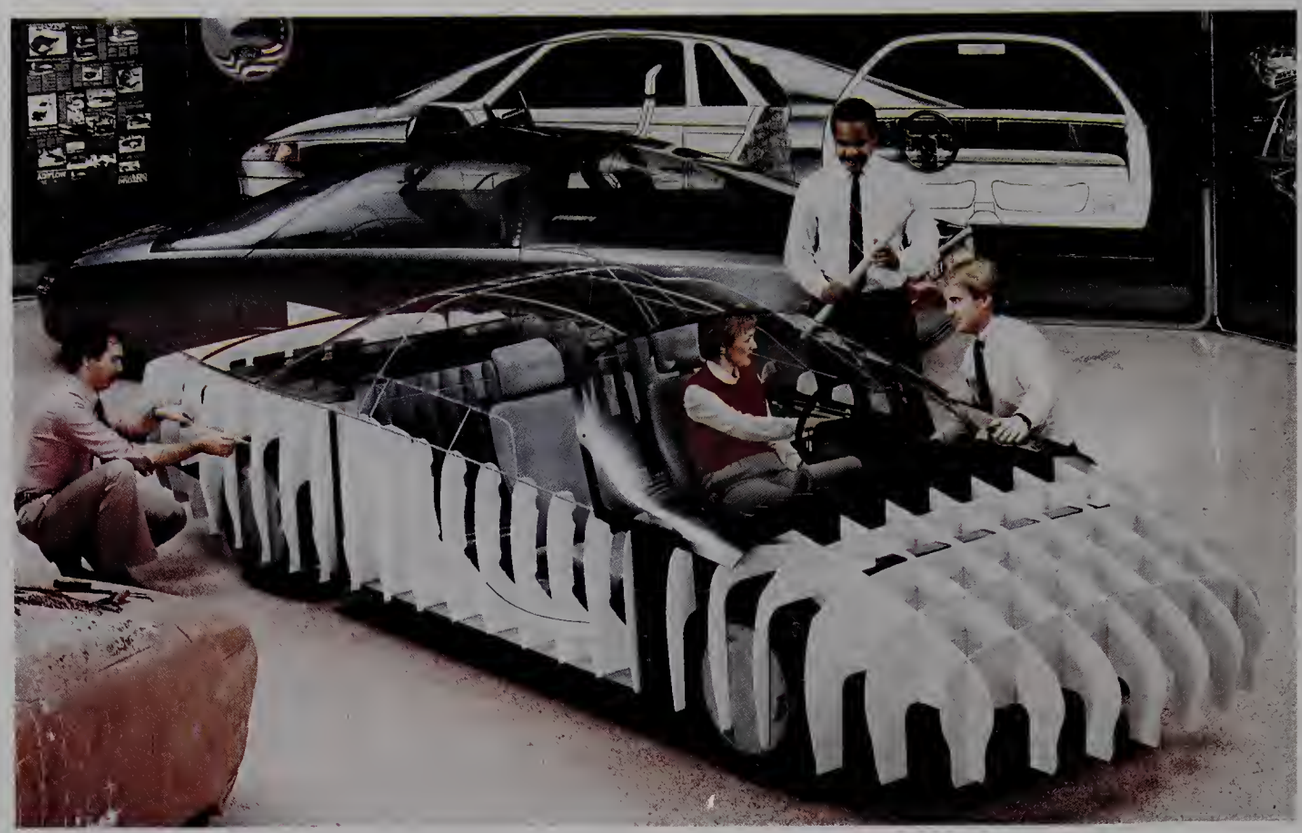


Fig. 18-15. These designers are using a mock-up of a new automobile to show its general appearance and styling features. (Motor Vehicle Manufacturers Assoc.)



Fig. 18-16. These balsa wood furniture mock-ups were built to show basic styling features.

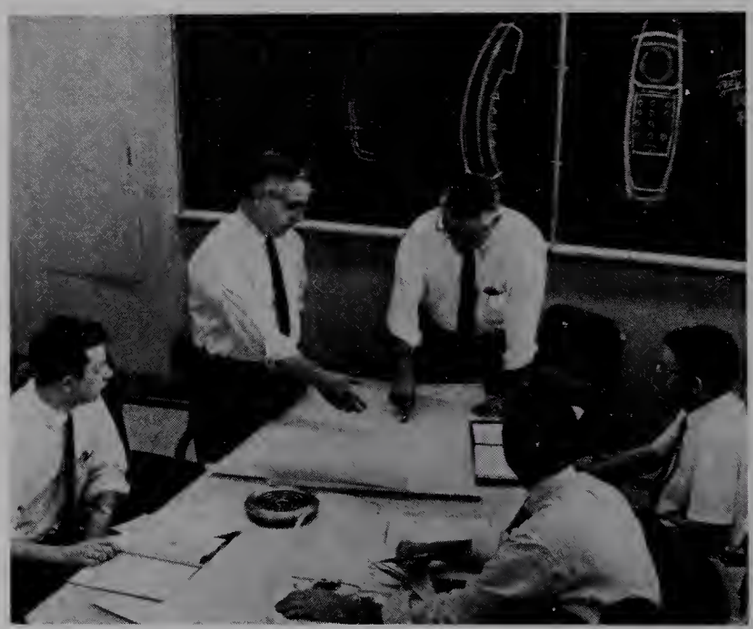


Fig. 18-17. These designers are developing details for a new telephone. (Western Electric Co.)

in Fig. 18-18, can be used by designers and product engineers to test the operation of the product.

Engineering testing

The prototype is important to personnel who complete the third phase of design and developing products. This phase is called engineering testing. It carefully tests prototypes or actual products to insure that they function, operate properly, and are safe.

Product weaknesses identified during engineering testing are subjected to redesign. The result should be a product that will meet the customer's expectations. Also, it should contribute positively to the company's image and profits.



Fig. 18-18. This toy designer is building a working model called a prototype. (Ohio Art Company)

SPECIFYING PRODUCT CHARACTERISTICS

Product design does not end with the prototype. Another market survey may be conducted to gather additional information about the product's acceptance. If the review of the prototype, engineering tests, and market survey results indicate that the product design is acceptable, then product specification activities will begin.

Communication between the product designer and the people who will build it is important. These groups may be hundreds of miles apart. Parts for the product may even be built by other companies.

If the product is to function, manufacturing personnel need accurate descriptions of the product's characteristics. They need to know the size, shape, and finish for each component.

Vital manufacturing information is communicated by three media produced by product designers. These are:

- Engineering drawings.
- Specification sheets.
- Bill of materials.

Each of these items communicates specific types of information. They are needed to communicate the total design.

ENGINEERING DRAWINGS

Engineering drawings are the most common way to show the size and shape of parts and products. Engineering drawings are produced by drafters working on drawing boards or at computer-aided design (CAD) terminals, Fig. 18-19. These drawings can be divided into three groups:

- Detail drawings.
- Assembly drawings.
- Systems drawings.

Detail drawings

Among the most important characteristics of a part is its size and shape. Most manufacturing processes are designed to alter these characteristics. Therefore, manufacturing personnel must have accurate size and shape information. This data is conveyed through detail drawings.

These drawings are usually two-view or three-view **orthographic projections**, Fig. 18-20. They show the part from either of two vantage points (usually front

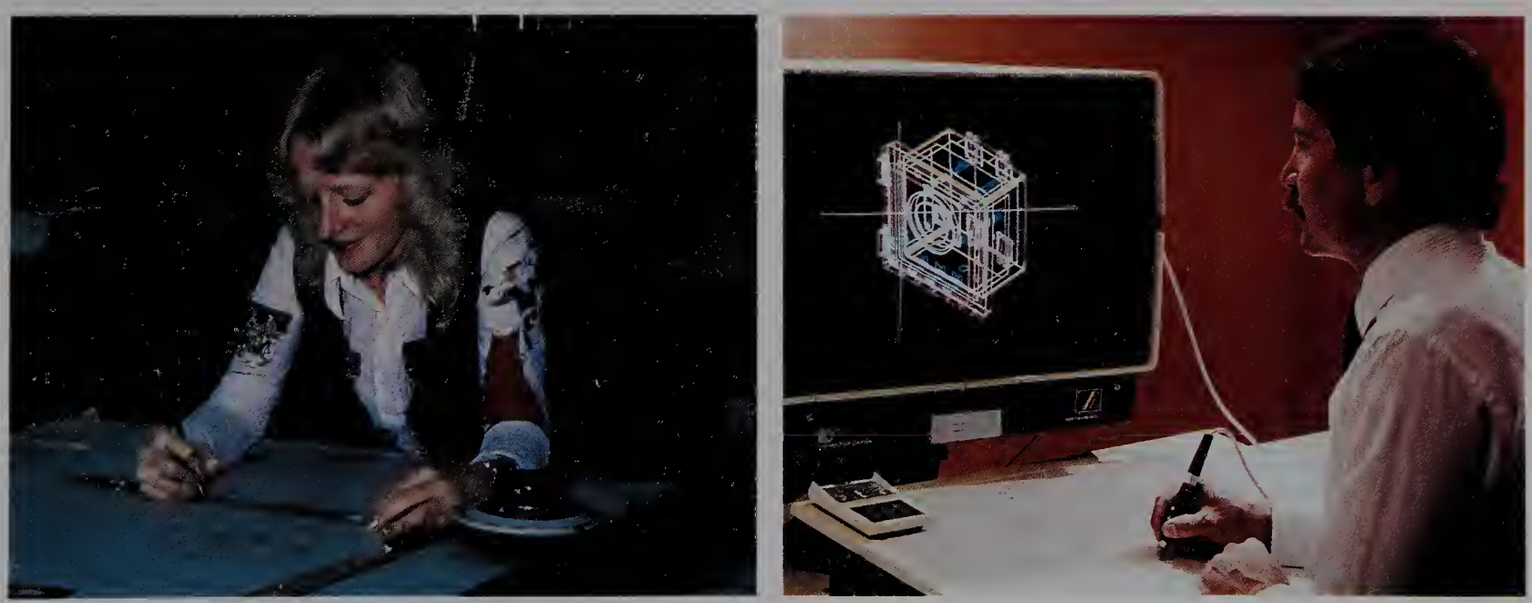


Fig. 18-19. The drafter on the left is using a typical drafting board and instruments, while the person on the right is using a CAD terminal to produce a drawing. (Ohio Art Co. and Crouse Hinds Div. of Cooper Industries.)

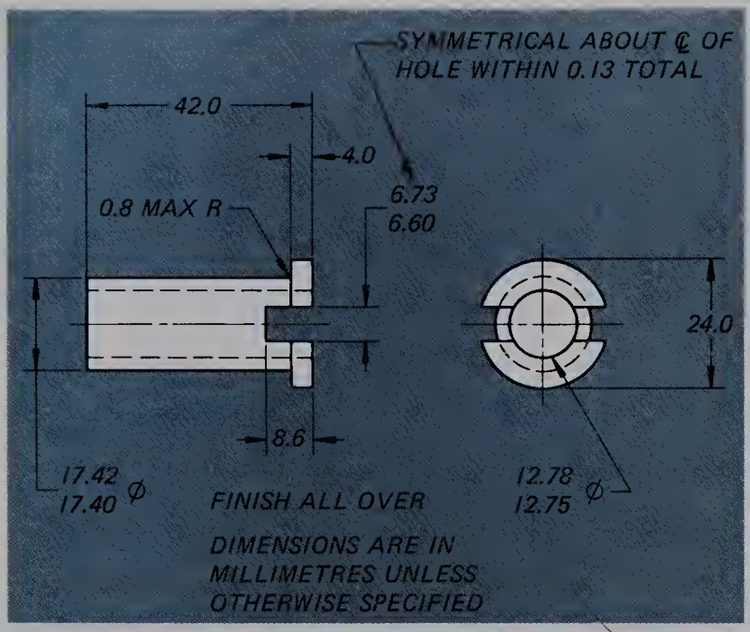


Fig. 18-20. This is a two-view orthographic drawing. Note that the dimensions are given using range, i.e. 17.40 - 17.42. (General Motors Corp.)

and side) or three vantage points (front, top, and right side).

Detail drawings provide size and shape information for a single part. They also give the size and location of all features such as, holes, notches, and grooves.

Each size on a detail drawing is indicated by a dimension and a tolerance. The **dimension** is the desired size. It is indicated by a line with a arrow at each end. The arrows show the points from which the linear distance is measured.

The **tolerance** is the amount a dimension can vary and still be acceptable. Typically, a dimension may be given as 0.250″ ± .015. This means the part is designed to be 0.250″ or 1/4″. However, any part that is between 0.235″ (0.025″ minus .015″) and 0.265″ (0.025″ plus .015″) will be acceptable.

A good detail drawing will contain all the information needed to manufacture the part. It gives a complete physical picture for the part.

Assembly drawings

Most products are multi-part devices. The parts are assembled into the finished product. The detail drawings show the size and shape of each part. The assembly drawings show how to put the parts together to produce a functional product, Fig. 18-21.

Systems drawings

Size and shape are not the only features that are important. In some cases, the relationship among components is important. For example, the location of components in a television is not as important as the way they are wired together, Fig. 18-22. This relationship is shown on systems drawings. These drawings are often called **schematics**. They are used to

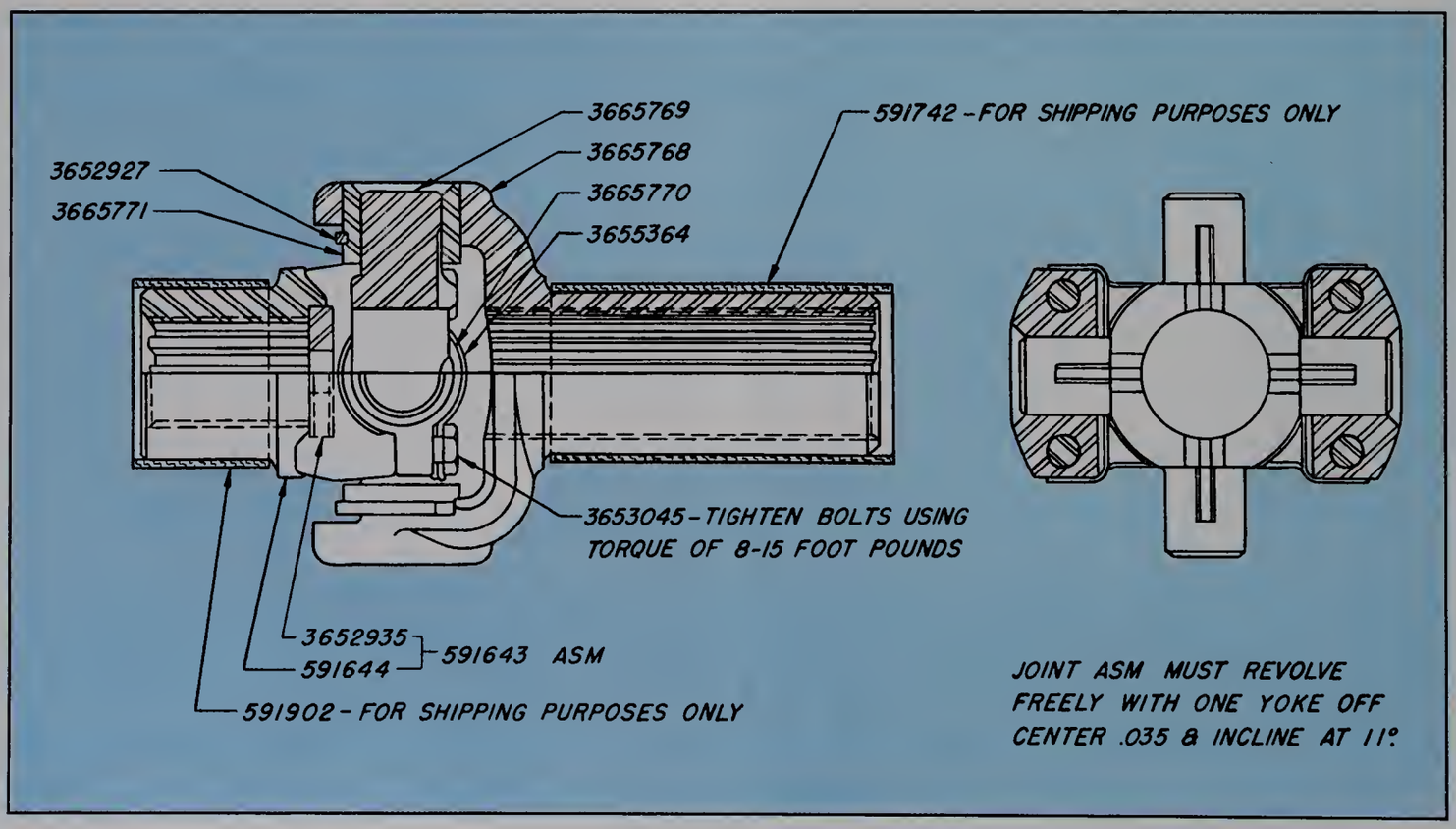


Fig. 18-21. This assembly drawing lists all the parts and their location in the product. (General Motors Corp.)

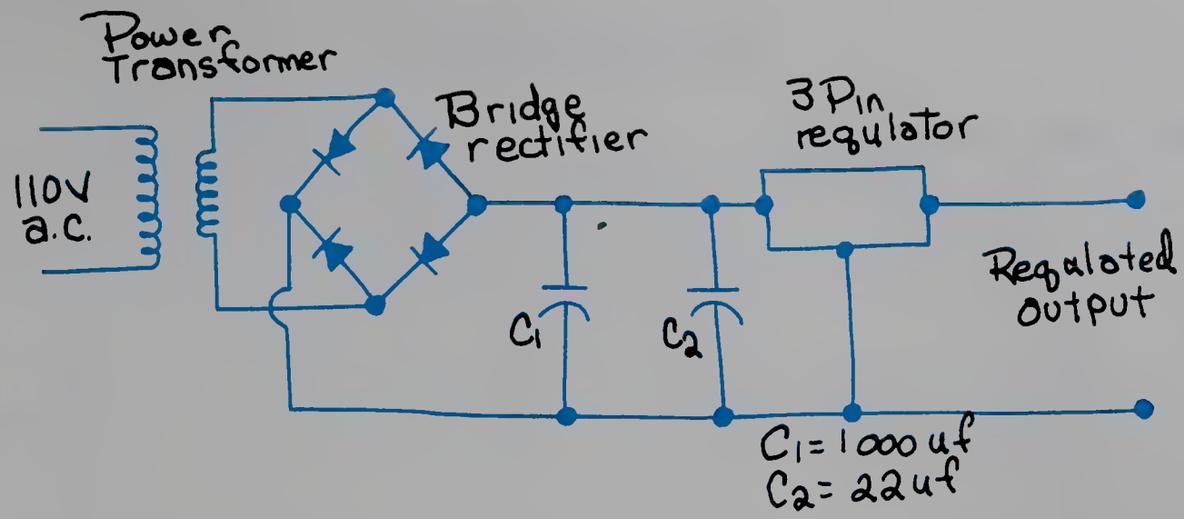


Fig. 18-22. This is a systems sketch. It shows the relationship among the electrical components in this circuit. It can be used as a wiring diagram.

communicate information about electrical, mechanical, hydraulic, and pneumatic systems.

SPECIFICATION SHEETS

Drawings cannot be used to communicate all information about a product. For example, it would be impossible to make a meaningful drawing for engine oil, steel, or abrasives. The size and shape of these materials is not the most important characteristic. They are selected for other properties, such as density, color, viscosity, tensile strength or coarseness.

In fact, drawings are seldom used to describe the characteristics of industrial materials. Instead, specification or technical data sheets are used, Fig. 18-23. Specification sheets contain important mechanical, physical, chemical, electrical, optical, thermal, or acoustical data for the material. This data is used to select a material for a product or other application.

PLASTIC SHEET LAMINATING GLUE # 7700

Ready to Use
No Staining
High Solids: 52-54%
Storage: up to one year
Quick Setting: 20-30 minutes

DESCRIPTION

USE

SPREADING

ASSEMBLY TIME

PRESSURE

PRESS TIME

STORAGE

Fig. 18-23. This is an outline for a specification sheet for a common cabinetmaking adhesive. (National Casein Co.)

BILL OF MATERIALS

Another way of specifying a product is with a **bill of materials**. This document, as shown in Fig. 18-24, lists all the parts and hardware items needed to make one product. These items are generally listed with manufactured parts first and purchased items last. Contrary to the common definition of a "bill," a bill of materials does not list the cost for each item. It actually is a list of materials needed to manufacture one product.

A complete bill of materials will list the following for each entry (part or hardware item):

- Part code number.
- Name of the item.
- Material to be used in making the part.
- Number of each item that will be needed.
- Size (thickness, width, length) of each part.

OBTAINING APPROVAL FOR PRODUCTION

With the completion of the product specifications, management must review the total development project. Management will take a last look at technical, economic, and market data, Fig. 18-25.

BILL OF MATERIALS

PRODUCT NAME: *Small utility box* **DATE:** *January 10, 19xx*

Part #	Part Name	Qty	Size			Material
			T	W	L	
001	End	2	3/8	3	4 1/4	Pine
002	Side	2	3/8	3	8	Pine
003	Top and Bottom	2	1/8	5	8	Hardboard
004	Hinge	2		1	2	Brass
	Wire nails	48	#18		1 1/4	Steel

Fig. 18-24. This is a bill of materials for a small box.



Fig. 18-25. Management must give final approval for products to be manufactured. (Ohio Art Co.)

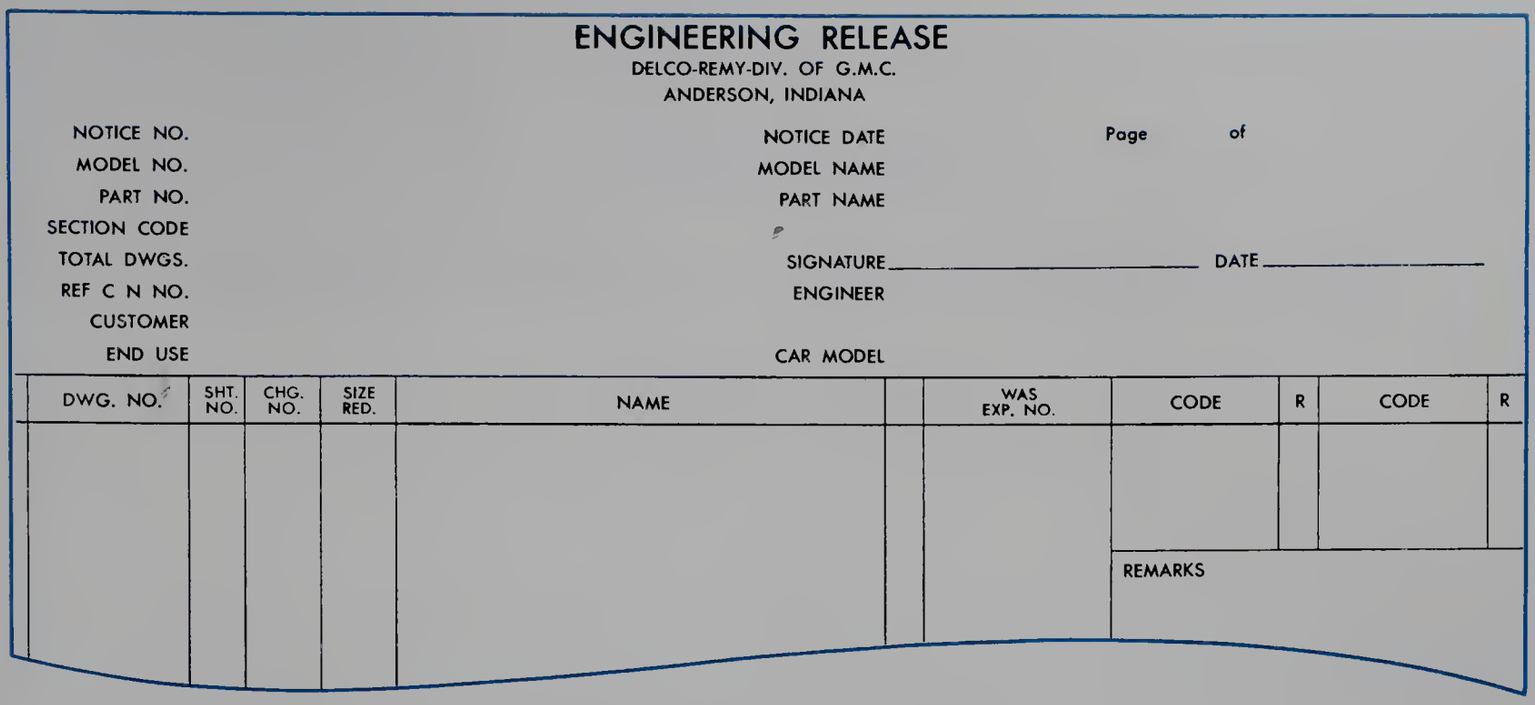
Management will often review a product in a formal manner, asking the design team to present the following types of information:

- The product.
  a. Need.
  b. Utility (usefulness).
  c. Sales appeal.
  d. Expected market demand.
  e. Advantages over the competition.
  f. Expected life.
- The market.
  a. Who it is.
  b. Size.
  c. Location.
  d. Buying habits.
- Financial needs.
  a. Development costs.
  b. Manufacturing costs.
  c. Expected profit.
- Company considerations.
  a. Fit with other company products.
  b. Fit with manufacturing capabilities.
  c. Fit with company marketing efforts

The management team weighs each of the points presented. They may use a rating scale to help them reach a conclusion. If the product meets their expectations, it will be released for manufacture. A drawing release form, Fig. 18-26, will be completed to send the drawings to the manufacturing area. This will trigger a number of activities that will be discussed in the next several chapters.

SUMMARY

Developing and designing products is a carefully planned activity. It is often driven by a product profile that describes the type of product a company is seeking. Product ideas are sought from a number of sources. These ideas are developed through several stages. Rough sketches are used to capture design ideas. These sketches are refined into more formal product ideas. These ideas are screened to select the most promising ones. They are then developed using renderings and mock-ups to define the appearance of the product. Detail sketches and prototypes are produced to help engineer the functional features of the product. Finally, the developed product is specified through drawings, bills of materials, and specification sheets. Products that meet company expectations are released for production.



ENGINEERING RELEASE

DELCO-REMY-DIV. OF G.M.C.
ANDERSON, INDIANA

NOTICE NO. NOTICE DATE Page of
MODEL NO. MODEL NAME
PART NO. PART NAME
SECTION CODE
TOTAL DWGS. SIGNATURE _____ DATE _____
REF C N NO. ENGINEER
CUSTOMER
END USE CAR MODEL

DWG. NO.	SHT. NO.	CHG. NO.	SIZE RED.	NAME		WAS EXP. NO.	CODE	R	CODE	R

REMARKS

Fig. 18-26. A drawing release form is often used to release a new product for manufacture. (Delco Remy Div. General Motors Corp.)

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

bill of materials
detail design
dimension
engineering data
engineering drawings
financial data
market approach
market information
market profile
marketing data
marketing system information
orthographic projections
preliminary design activities
product developers
product information
product profile
production approach
refined sketches
rough sketches
schematics
test market
tolerance

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the six major product design steps used in product development.
2. Distinguish between the market approach and the production approach used to develop products.
3. Name five elements that must be included in a product profile.
4. Marketing data presented to a product review team includes information on the potential _____.
5. Generally, a customer is first attracted to a product by its:
   a. Cost.
   b. Weight.
   c. Appearance.
   d. Strength.
6. True or False? A prototype is produced before a mock-up is made.
7. Which of the following drawings are usually two-view or three-view orthographic projections of a product?
   a. Detail drawings.
   b. Assembly drawings.
   c. Systems drawings.
   d. None of the above.
8. Once product specifications have been completed, approval for production must be obtained from _____.

APPLYING YOUR KNOWLEDGE

1. Survey 20 people in your school to determine the types of products costing less than $5.00 that

they expect to buy in the next two months.

a. Decide on a list of questions to ask in your survey.
b. Design a questionnaire so you will be able to record the answers to your questions.
c. Suggestion: Target the market you want to reach. Should the market be students only, teachers only, parents only, etc.?

2. Select a product you have purchased in the last six months. Analyze the product in terms of its design for manufacture, selling, and function. On a form like Fig. 18-A, list three features that represent each of these design concerns.
3. Develop a bill of materials for the trivet that was produced in the activity in Chapter 9. Use a form similar to the one shown in 18-B.

DESIGN CONCERN	PRODUCT FEATURE
FUNCTION	1. _____ 2. _____ 3. _____
MANUFACTURE	1. _____ 2. _____ 3. _____
SELLING	1. _____ 2. _____ 3. _____

Fig. 18-A. On a separate sheet of paper, prepare a form similar to this one on which to record your responses.

Product: *Trivet* Prepared by: _____

Part No.	Qty.	Part Name	Size			Material
			T	W	L	

Fig. 18-B. On a separate sheet of paper, prepare a form similar to this bill of materials.

19

CHAPTER

DEVELOPING A PRODUCTION SYSTEM

After studying this chapter, you will be able to:

- *Select and properly sequence manufacturing operations.*
- *Describe how a manufacturing facility (plant) is engineered.*
- *Explain how production tooling is designed and fabricated.*
- *Determine how a quality assurance program should be established.*

The product has been developed. Drafters have completed and released detail and assembly drawings. The bill of materials and specification sheets are available. The product is ready to be manufactured, or is it?

Where is it going to be produced? Where are the factory, machines, and people? What operations will be used to make the parts and assemblies? How will product quality be maintained? These are just a few of the manufacturing challenges that must be met before the product can be actually produced. Every manufacturing enterprise faces these "where" and "how" questions when a new product is produced. The success of the company will rest, to a great extent, upon the answers to these critical questions. The key to success is careful planning of manufacturing systems before making the product.

The "six P's of successful manufacturing" summarize the importance of production planning: Proper prior planning prevents poor performance (and poor profits). See Fig. 19-1.

The proper planning for manufacturing involves four basic tasks. They are:

1. Selecting and sequencing all of the manufacturing operations.
2. Engineering the manufacturing facility (plant).
3. Designing and fabricating production tooling.
4. Establishing a quality assurance program.

These four steps have a direct relationship to the four production functions given in Chapter 15. You may recall that these functions are manufacturing

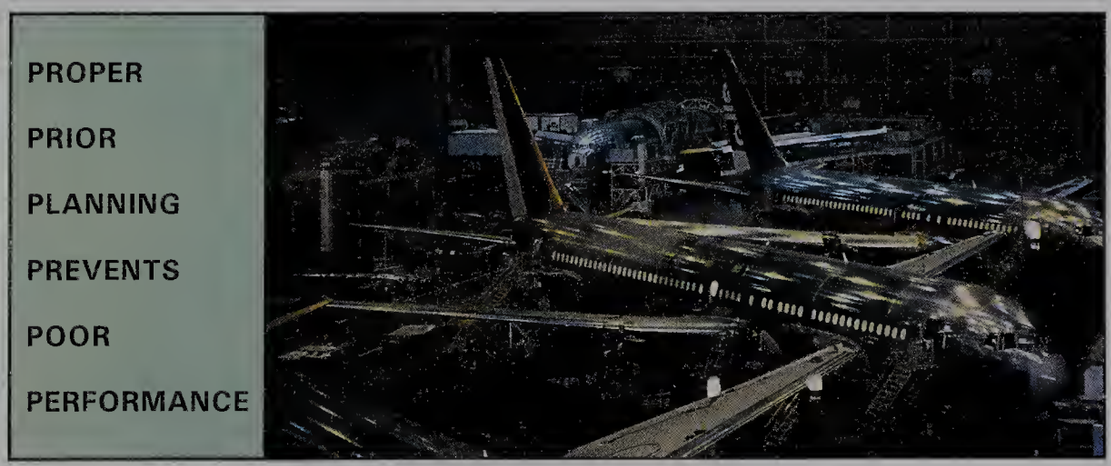


Fig. 19-1. Products like these airplanes are the output of carefully planned manufacturing systems. (Boeing Co.)

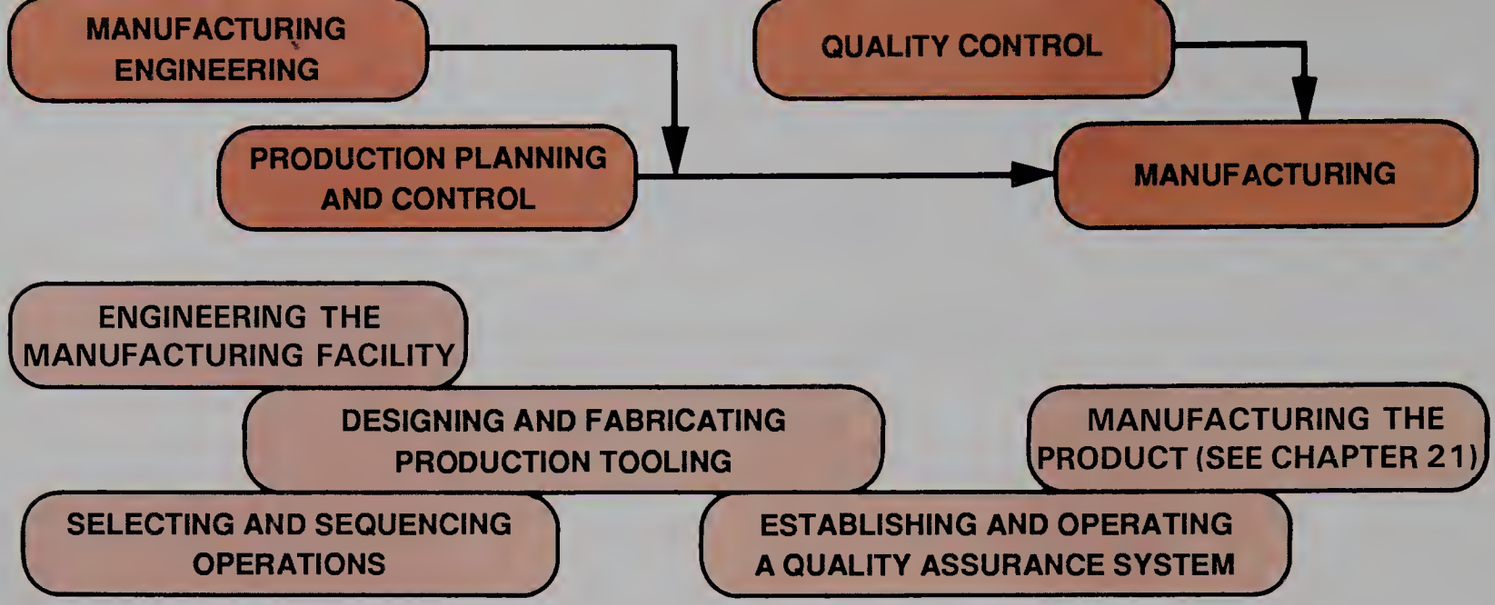


Fig. 19-2. The functions of production and the activities associated with them are diagramed here.

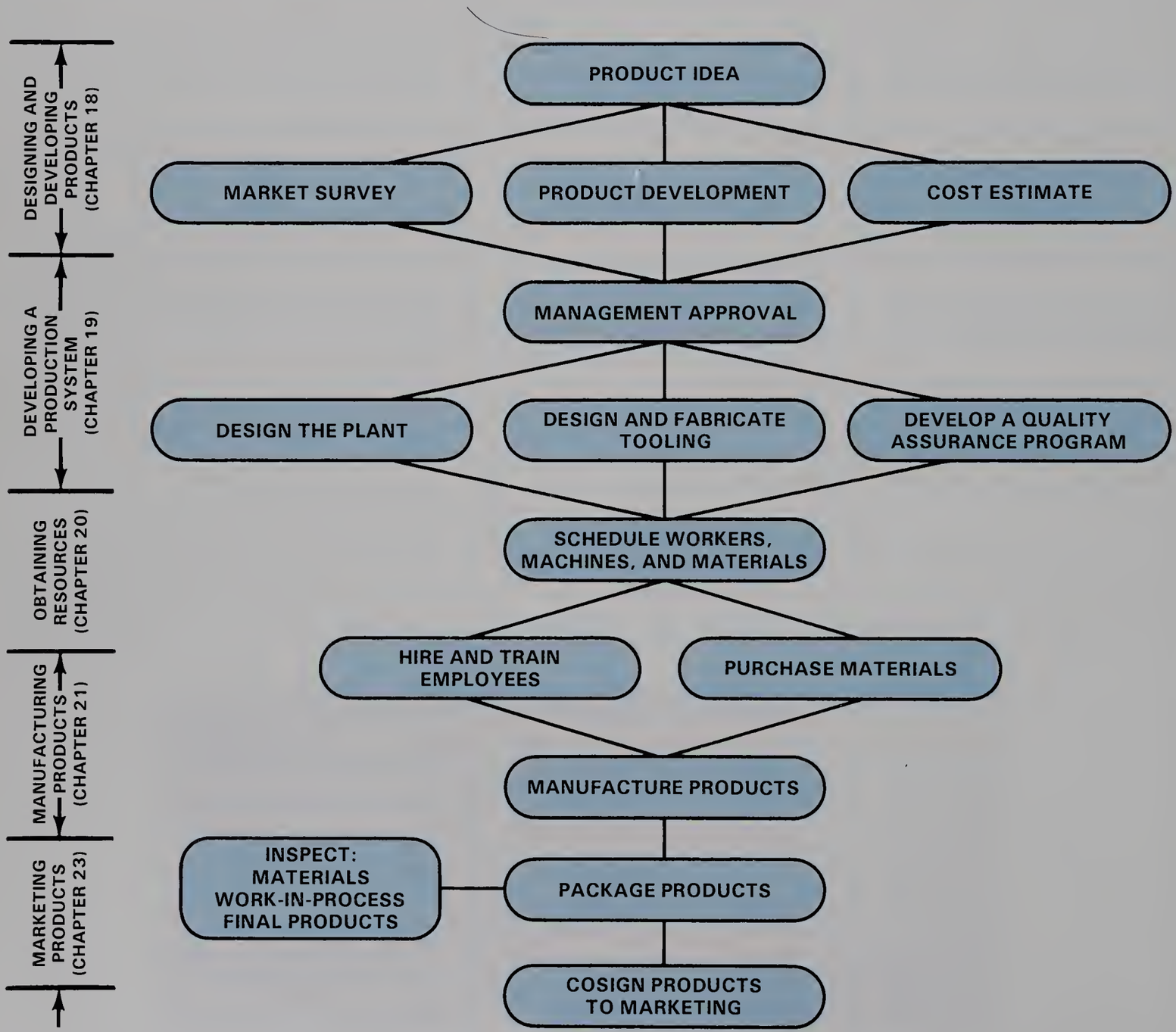


Fig. 19-3. Many activities contribute to moving a product from a designer's mind into reality. You will study these activities in the chapters listed on the left.

engineering, production planning and control, manufacturing, and quality control. Fig. 19-2 shows the relationship between production functions and tasks. You may also notice that several steps overlap one another. This suggests that the information developed in one step provides direction for other steps.

Moreover, these production planning tasks are part of a larger picture. They use information developed through product design and engineering activities. They have an impact on other tasks such as employment, product manufacturing, and marketing. The relationship between product development and manufacturing steps is shown in Fig. 19-3.

SELECTING AND SEQUENCING OPERATIONS

A company faces many challenges when developing a system to manufacture a new product. An early decision is made to determine how the product will be made. This task is often called **methods engineering**.

All products are made from materials that are changed in size, shape, and/or composition. This change occurs through manufacturing processes. However, not just any group processes will work. Efficient manufacturing is accomplished by using the *right process* at the *right time* to change the form of the *right materials*, Fig. 19-4.

Methods engineers must select the operations that will be used to make a product. Then these operations are related to one another. This goal is reached by completing the following five tasks for each part and assembly:

1. Listing the tasks needed to make the product. This includes identifying all operations, material movements, product inspections, delays, and storage acts.
2. Analyzing and evaluating the tasks. This involves four steps:
   a. Questioning the purpose of each task.
   b. Determining if each task is needed.
   c. Deciding where, when, and by whom each task will be completed.
   d. Investigating the best way to complete tasks.
3. Deciding which is the best method of manufacturing the product. This task is accomplished by:
   a. Combining, arranging, and simplifying all the manufacturing steps. This includes operations, inspection, and material movement.
   b. Eliminating all delays and storage acts.
4. Presenting plans to management for approval.
5. Implementing production methods. (Setting up production systems.)

Methods engineers use two major documents in completing their work. The first is a flow process chart, while the second is an operation process chart.

FLOW PROCESS CHART

Most products have several parts. Each of these parts is individually manufactured. Most of these parts require their own unique set of production processes. This arrangement of processes must be recorded and studied. The most common way to do this is the **flow process chart**.

Manufacturing or industrial engineers develop the flow process chart. They use product drawings, specifications, and bills of materials as data sources. From these sources, they begin to select and sequence the actions needed to make the product.

The flow process chart uses a set of symbols, Fig. 19-5, and written descriptions to show how a part is made. The chart, like the one shown in Fig. 19-6, graphically shows all the production acts required to make a single part. These acts are divided into five groups: operations, transportations (movement), inspections, storages, and delays.

The flow process chart also may list:

- Operation and inspection numbers.
- Distances materials are moved by all of the transportation acts.
- Production levels in products per minute or hour.
- Special machines, such as tooling machines and cutters, that are needed.
- Other important information.



Fig. 19-4. Methods engineers develop efficient manufacturing methods to produce products. (Crouse-Hinds Div., Cooper Industries)

SYMBOL	TITLE	MEANING
	OPERATION	Object is changed in its chemical or physical makeup. It is assembled or disassembled.
	TRANS-PORTATION	Object is moved from one place to another.
	INSPECTION	Quality of the object is checked.
	DELAY	Object is held awaiting the next operation.
	STORAGE	Object is placed in a protected location.

Fig. 19-5. A flow process chart uses these symbols to show various manufacturing actions.

Flow process charts are used to develop manufacturing systems for new parts. They may also be used to study existing systems. Using these charts, engineers can seek answers to the following questions:

- Is each operation necessary?
- Can several operations be combined?
- Is the order of operations correct?
- Can operations and inspections be simplified?
- Are all transportations necessary?
- Can storages and delays be eliminated?
- Is there a better way to organize the entire process?

Answers to these questions can lead to additional studies. Specific operations may be studied to improve their efficiency. Worker actions and comfort may be changed to increase productivity. The workstation may be rearranged to reduce unnecessary reaching and awkward actions. Lighting may be changed to make the work more pleasant.

XYZ CORPORATION
FLOW PROCESS CHART

PRODUCT: # 101 Deluxe Birdhouse **PART:** Side

TASK	DESCRIPTION	DISTANCE	RATE
	Move to cut-off station.	5 feet	
	Cut part to length.		50 min/100
	Move to ripping station.	6 feet	
	Rip to width.		55 min/100
	Move to sanding.		
	Sand sides and edges.		95 min/100
	Move to inspection.		
	Inspect size and sanding.		20 min/100
	Move to storage.	20 feet	
	Store for assembly.		

Fig. 19-6. This sample flow process chart shows the manufacturing acts needed to make one part.

In this process, the goal is to improve each operation and the entire production system. The industrial or manufacturing engineer will attempt to:

- Make all operations comfortable for workers.
- Ensure that all materials and parts are within easy reach.
- Balance the use of right and left hands.
- Locate machine control in convenient places.
- Improve the safety of the operations.

OPERATION PROCESS CHARTS

A flow process chart focuses on a single part. A typical product, however, is made from a number of different parts, Fig. 19-7. Therefore, the product would have a number of flow process charts. However, these charts do not give the entire picture. For example, where do the parts come together to make assemblies and products? Can inspections of several parts be combined? Which parts must be manufactured first? These and other questions can be answered through an **operation process chart**.

This chart graphically shows all the operations and inspections needed to produce a product. It also shows where the parts come together to form assemblies and products.

Look at Fig. 19-8 to see how the chart communicates the manufacturing process. Generally, industrial materials (standard stock) enter the top of each branch. The materials are processed into parts as they move down the branches. The branches merge into a stem as the parts are assembled. The finished product leaves the system at the bottom of the chart.

ENGINEERING THE MANUFACTURING FACILITIES

Selecting and sequencing operations are only part of the planning needed for product manufacturing. Operations are completed in a factory. This facility must be designed. It involves placement of machines and other equipment in order to promote the flow of people and materials. This action is called **plant layout** and involves:

- Assigning space within the plant.
- Arrange equipment within the assigned space.

Material handling engineering is closely related to plant layout. This task involves designing and installing systems to move materials and products through the manufacturing plant.

Plant layout and material handling engineering should promote efficient manufacturing through effective use of machines, materials, and people. In automobile travel, as well as in manufacturing, traffic tie-ups, bottlenecks (slow downs), and back tracking create inefficiencies. Wasted time and travel



Fig. 19-7. Products are usually made from a number of parts. The total manufacturing system is often detailed on an operation process chart. (Zero Corp.)

often add costs, increase hazards, and lower product quality. A well-organized plant will reduce these inefficient activities.

PLANT LAYOUT

Plant layout personnel use several sources of information in their work. These include data on the:

- Product design–drawings, specifications, etc.
- Estimated production volume–products per day, week, month, etc.
- Manufacturing sequence–flow process charts.
- Assembly sequence–operation process chart.

From this information, an appropriate plant layout is developed. This layout should use the least amount of space needed to support efficient product production. The layout should:

- Effectively allow people to use machines to process materials.
- Require a minimum of movement of people and machines.
- Provide for the sequential flow of materials as they move through processing steps.
- Give workers a safe work environment that meets OSHA standards.
- Be flexible and easily changed.

To accomplish this challenge, plant engineers use one of two basic types of plant layout: process and product. The system chosen will be determined by the number operations, type of manufacture (custom,

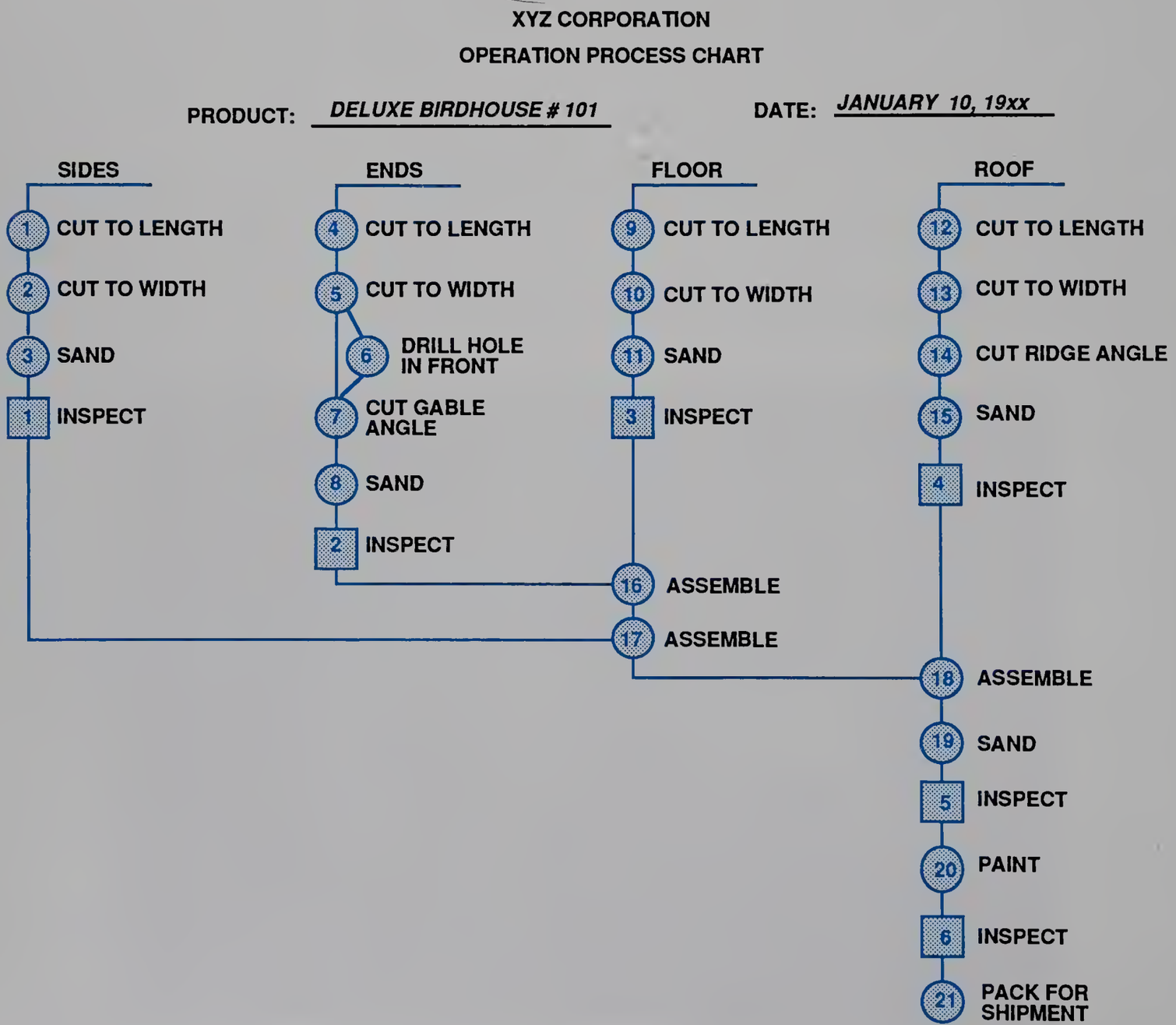


Fig. 19-8. This is a typical operation process chart. It shows the orderly sequence of operations and inspection needed to manufacture a product.

intermittent, continuous, flexible), and the shape of the building.

Custom and intermittent manufacture use **processes layout**. All equipment that performs the same processes is grouped together. This often results in departments taking their names from processes. Examples of process layout departments include welding departments, finishing departments, etc.

Continuous manufacturing uses **product layout**. The equipment needed to produce a product is placed in an orderly line. Its location is determined by the sequence of operations needed to produce the product. This results in departments being named after product parts such as the armature department, chassis department, etc.

Continuous lines are organized in one of five basic patterns. These, as shown in Fig. 19-9, are straight line, S-shaped, U-shaped, circular, and random angle.

Assembly operations usually require a **branched layout**. Subassemblies are produced on branches that feed the main stem. The product takes shape as it travels along the line. The most common branched lines are one-sided and two-sided, Fig. 19-10.

In designing manufacturing lines, engineers must consider workers, machines, and materials. The workers must have safe, efficient workstations. Materials and parts must move to proper locations on the line without damage. Machines must be located near utilities such as water, electricity, natural gas, and compressed air. Noise and fumes must also be controlled.

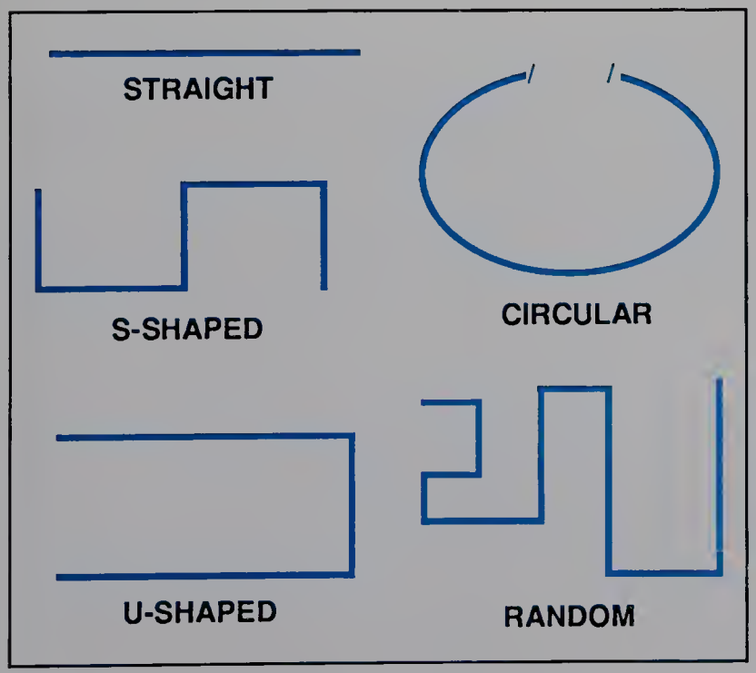


Fig. 19-9. Plants are laid out in one of these five basic ways or with a combination of them.

Engineers develop and communicate their plant layouts using three major techniques. These, as shown in Fig. 19-11, are:

- Drawings with overlays (clear lay-over sheets) to show machine placement and flow lines.
- Two-dimensional templates (machine outlines cut from heavy paper) attached to a floor plan.
- Three-dimensional scale models placed on the floor plan.

MATERIAL HANDLING

Every manufacturing plant must have a way to move materials from storage onto the production line and, then, along the line. This action is called **material handling**. It includes all acts that pick up and move materials within a factory.

Material handling systems are designed to move three types of items. These are materials, work-in-process, and finished products. The system moves these items out of storage, between workstations, and back into storage. Material handling may use people to carry the items to the desired location. However, most systems are mechanical. They involve technological means to move the materials or products.

All material handling systems must move the materials, parts, and products safely and without

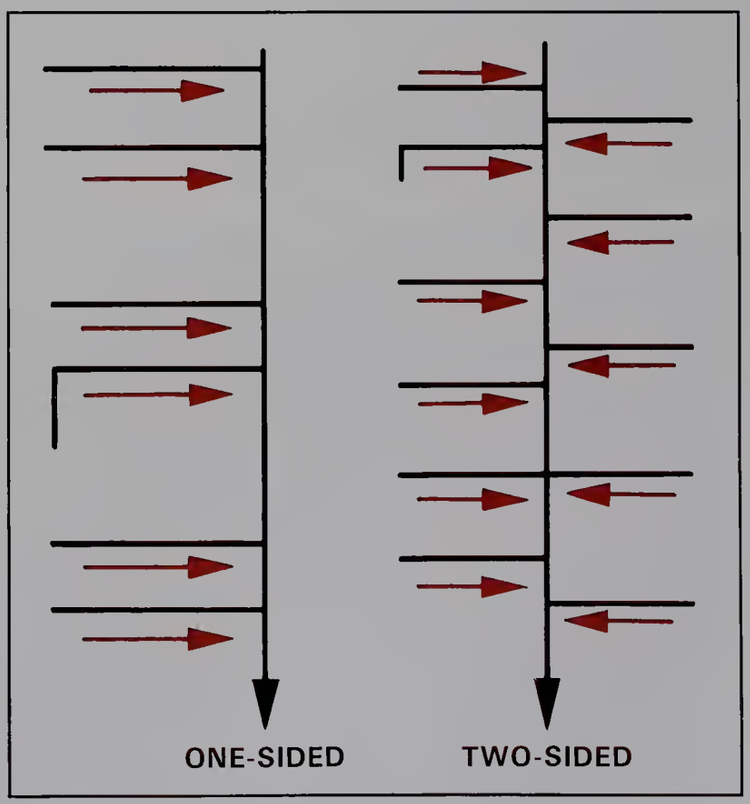
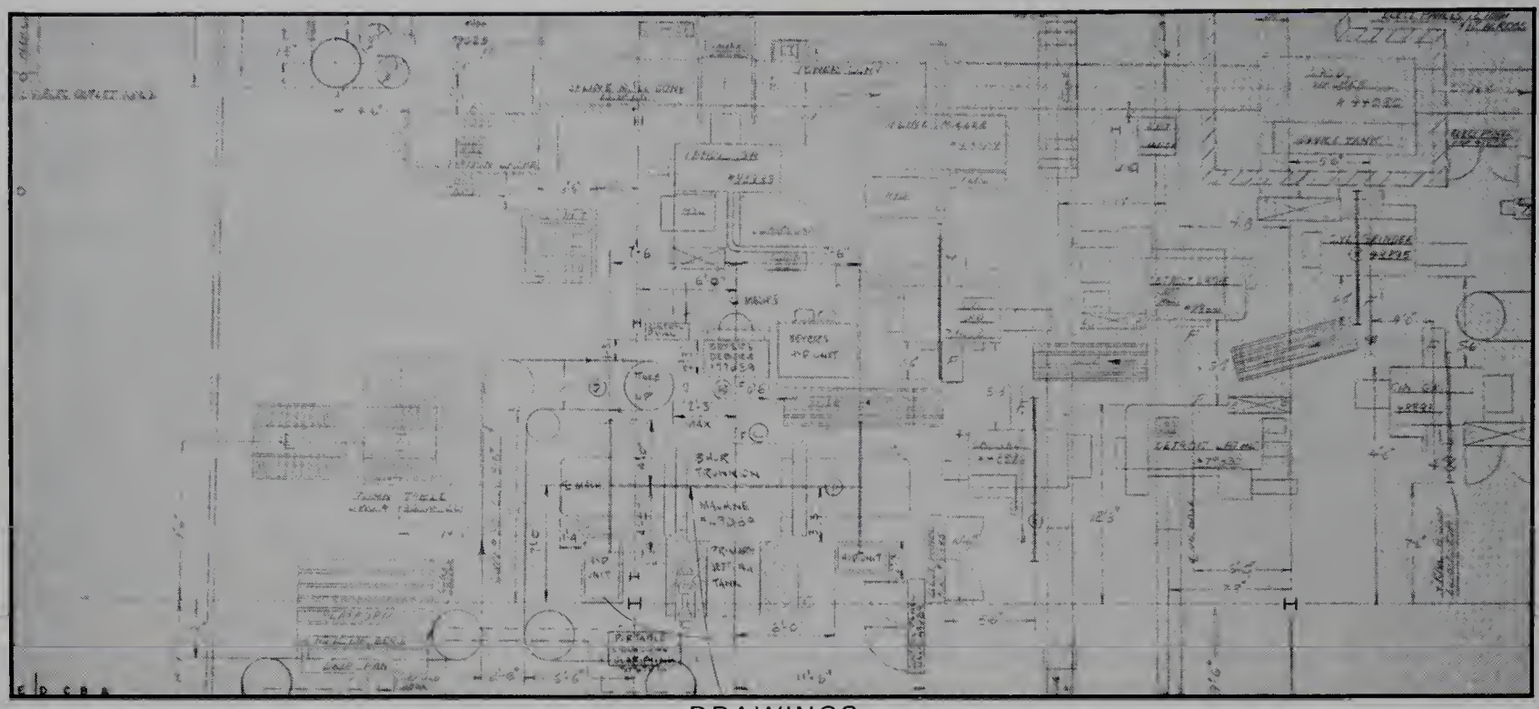
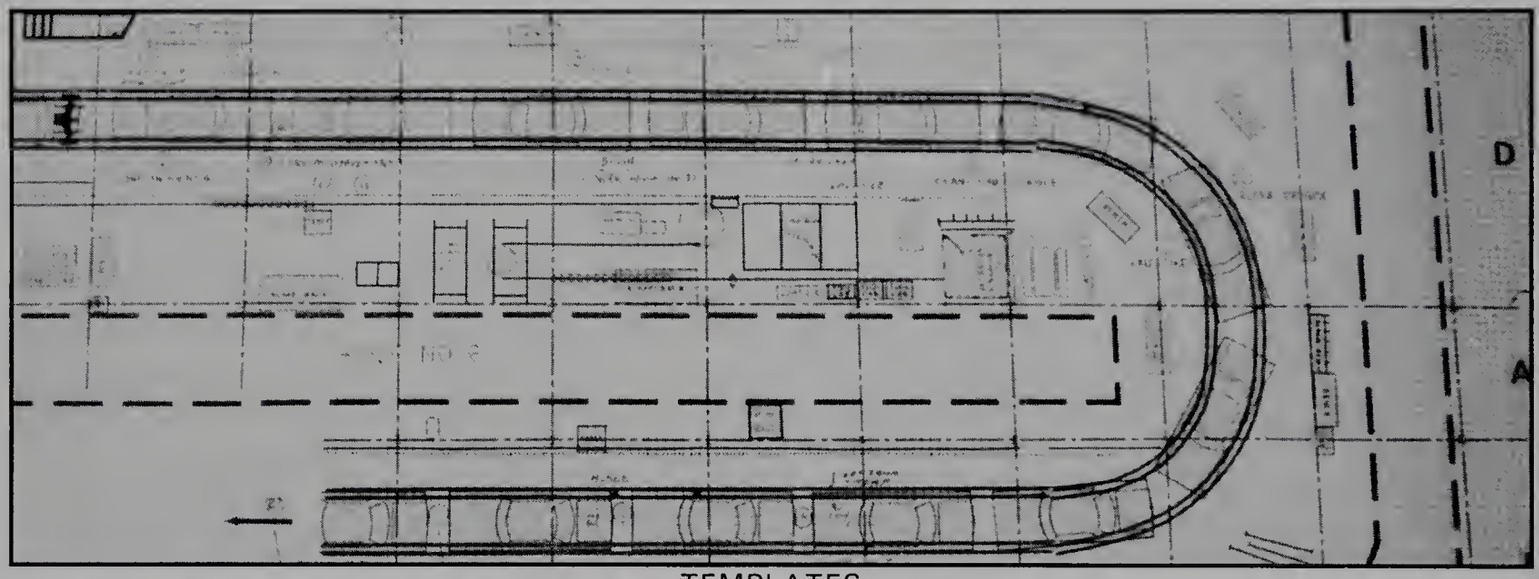


Fig. 19-10. Branched layouts are often used in assembly lines. Parts may be fed from one side or both sides of the main or trunk line.



DRAWINGS



TEMPLATES



SCALE MODELS

Fig. 19-11. Plant layouts are communicated by drawings, templates on floor plans, or by three-dimensional models.

damage. They are designed for many forms of materials. This may include liquids, granules, flakes, powders, sheets, or gases. The materials may be heavy, light, sticky, explosive, corrosive, or slippery. Each material handling system is carefully designed to meet the special requirements of each product.

Material handling systems can be divided into two groups, Fig. 19-12. There are systems that use fixed path systems and those that use variable path or steerable systems.

Fixed path systems

Continuous manufacturing systems have production lines along which products travel. The products move from machine to machine in a fixed path. This path is highly predictable and seldom changes. This type of manufacturing system effectively uses material handling systems that always move the part from Point A to Point B. These types are called **fixed path systems**.

Typical fixed path systems are conveyors, chutes, augers, and pipes. These devices are fairly expensive to install, but they are inexpensive to operate. A drawback is that when the fixed path system stops, all manufacture must also stop. Fixed path systems are closely tied to the plant layout and the product being manufactured.

Variable path systems

Custom, intermittent, and flexible manufacturing are designed to produce a number of different products on the same machines. Each product will probably have a different production path. Material movements are not set and often cross, backtrack, and change. This requires **variable path systems** that are flexible material handling systems.

Typical equipment used for variable path systems are robot transporters, forklifts, carts, hand trucks, and wheelbarrows. Most of these systems require human operators. They are, therefore, more expensive to operate than fixed path systems.

DESIGNING AND FABRICATING PRODUCTION TOOLING

Designing the material handling system and plant layout establishes the primary part of the manufacturing facility. However, the system is not complete, Fig. 19-13. Manufacturing is based on the *interchangeability of parts*. Like parts must fit any like product.



Fig. 19-13. The installation of machines and material handling devices develops the manufacturing plant. However, tooling is needed to make operations safe, efficient, and accurate. (PPG Industries)

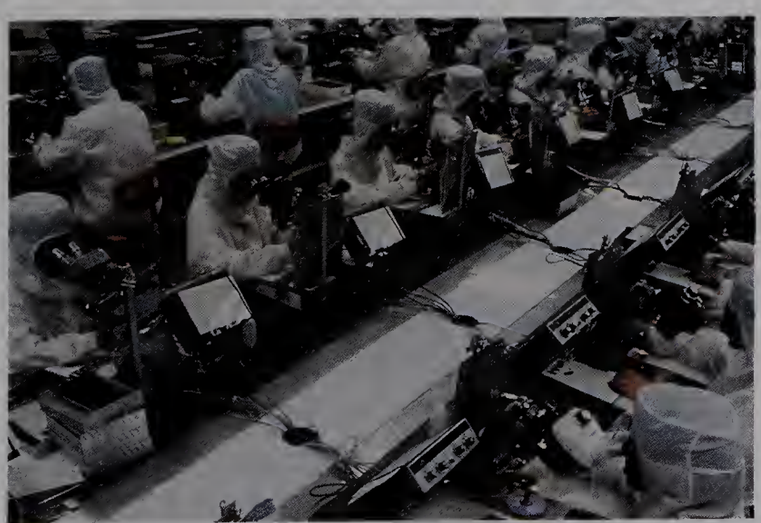




Fig. 19-12. Material handling devices may use fixed path (left) or variable path (right) mechanisms. (Harris Corp.)

This provides a unique challenge. Parts must be made to specification. Tolerances must be held. To meet this goal, manufacturing systems require special devices that increase the speed, accuracy, and safety of the production processes. These devices are called **production tooling**.

DESIGNING TOOLING

In the chapters in Section 3, you studied manufacturing processes. You were also introduced to tooling devices. These included casting molds, forming dies, assembly fixtures, special cutters, and clamping devices. These devices are designed to meet one or more of the following tasks:

- Position and clamp the workpiece for accurate size control.
- Guide a cutter or forming device.
- Support the work during the processing act.
- Form or shape materials.
- Make setup easier.
- Increase the efficiency of an operation.
- Provide for safe machine operation.
- Provide for chips and other waste.

Designing tooling is a complex assignment. It requires a knowledge of manufacturing processes and material characteristics.



Fig. 19-14. Fixtures, jigs, patterns, templates, and special tools and dies, like this tire mold, are called tooling. (Goodyear Tire and Rubber Co.)

Production tooling can be grouped into four categories, as shown in Fig. 19-14:

- *Fixtures:* Devices that position and hold a workpiece, such as a welding fixture or drill press vise.
- *Jigs:* Devices that position and hold the workpiece and guide the cutting tool, such as a drilling jig.
- *Patterns and templates:* Devices that provide the outline and contour of the part to be produced, such as a foundry pattern or a layout template.
- *Special cutters and dies:* Devices designed to form, machine, or shear materials to a desired shape such as shaper cutters and forging dies.

GUIDELINES FOR TOOLING DESIGN

Each type of tooling has its own design considerations. However, some general guidelines can be applied to several different types. These include:

- Clamping the work.
  a. Keep the pressure low. Too much pressure will cause the material to bend out of shape or to pop out of the tooling. Also, excess pressure can damage the tooling itself.
  b. Apply clamping pressure in a direction that seats the part in the tooling, Fig. 19-15.
- Supporting the work.
  a. Support the work securely to resist the cutting forces, Fig. 19-16.
  b. Support under the work should be provided to reduce deflection and vibration.
- Locating the part for dimensional control.
  a. Determine the dimensions that are critical and those that can accept the tolerance.

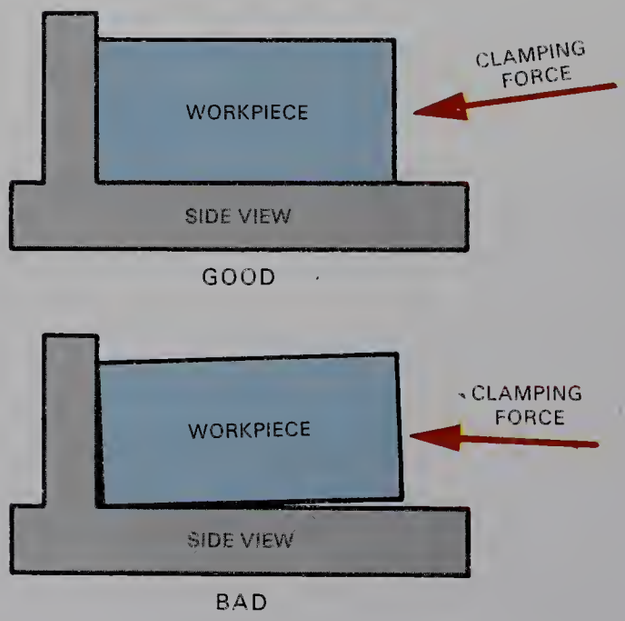


Fig. 19-15. Clamping pressures should seat the part into the tooling. Notice in the above views that a change in the clamping angle pushed the part into position.

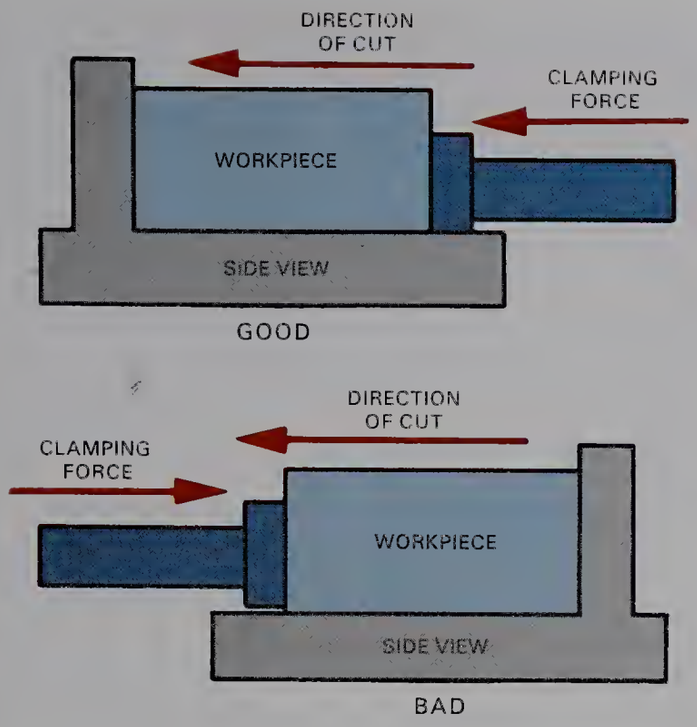


Fig. 19-16. The solid part of tooling should receive the force caused by the cutting action.

   b. Keep dimensional errors away from the critical dimensions.
   c. Index the part from the same point or surface. This is called a *datum point* or *datum surface*.
   d. Avoid using templates for drawing lines onto parts.
   e. Remove as much human judgment as possible in locating parts and positioning them under cutters.
- Ease of setup.
   a. Allow for quick attachment and removal from machines.
   b. Use table edges, miter gage grooves, and table slots for easy positioning.
- Ease of operation.
   a. Provide for easy part loading, clamping, and unloading.
   b. Remove as much operator judgment and skill as possible.
   c. Provide for easy adjustment for tool wear and cutter position.
- Chip provisions.
   a. Avoid areas where chips will gather and affect accuracy.
   b. Provide for easy chip and other residue removal, Fig. 19-17.
- Safety.
   a. Avoid unsafe loading, operation, and unloading practices.
   b. Provide all necessary guards and shields.
   c. Provide mechanical methods for holding small parts.

Well designed tooling increases product quality. It also reduces the need for operator skill in producing the product. The result is a higher quality product manufactured at a lower cost.

ESTABLISHING A QUALITY ASSURANCE PROGRAM

Consumers expect products to work properly. They expect them to be free of defects. They also expect products to last as long as the manufacturer said they would. In short, consumers expect quality products.

What is a quality product? The word *quality* is often misunderstood. It does not mean perfection, long life, or freedom from defects. Quality means meeting stated design standards. You would not expect a paper coffee cup to last for months or to hold gasoline. These expectations are beyond its intended use. You would expect it to hold a beverage for a short time. Likewise, you would not expect nails to have smooth surfaces, perfectly formed heads, and a highly polished appearance. These characteristics are unnecessary for the product to function properly. The key word is *function*. Products should do what they were designed to do.

Manufacturing industries have entered a new era. They are in a period where "world class" products are commonplace and expected. A **world class product** is one that works well, is easy to operate, and is

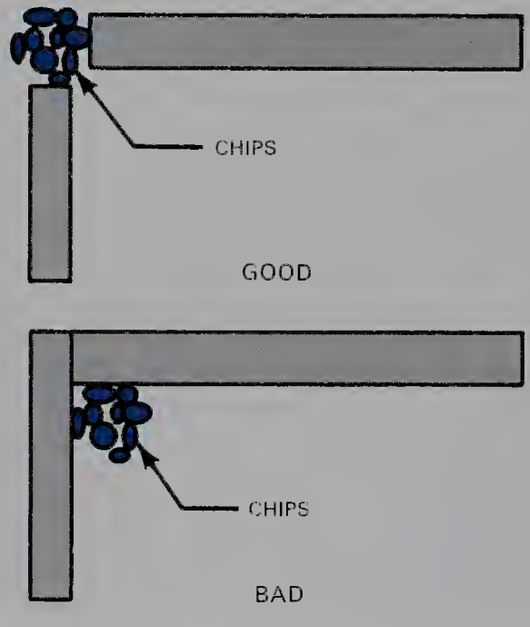


Fig. 19-17. Tooling should be designed to reduce chip buildup and for easy removal of chips and residue.

relatively inexpensive. This type of product is an outgrowth of Japanese industry. World-class is now the standard that every country's products must match.

World-class products demand a new corporate mentality (way of thinking). They require that quality is the focus at every step. Products are designed with quality in mind, Fig. 19-18. Manufacturing systems are developed to maintain quality. Products are produced by workers who believe their employment is assured by quality production. Management must believe that company success is directly related to the level of product quality. As you can see, quality is everybody's job and, as one company's slogan says, "Quality is Job 1."

We have already looked at quality in product design (designing for function, manufacture, and selling) and manufacturing system design (tooling, plant layout, and material handling design). However, no matter how effective these efforts are, mistakes can be made. Products are manufactured that do not meet standards. A "factory floor" program that is designed to reduce these mistakes is called **quality control**. It is designed to improve the level of quality related to the actual making of the product.

Quality control has two major thrusts. The first is attitude development and the second is inspection.

ATTITUDE DEVELOPMENT

Everyone has a set of attitudes or beliefs. People act on them every day. For example, what is your attitude about studying? Do you think it is important? If so, you will probably do your homework before watching television or going to a party.

Likewise, workers have attitudes about their jobs. Some workers see a job only as a way to earn money. The money lets them do what they really think is important. This type of worker may care little about the company and the product he or she produces. This attitude is shortsighted. Jobs are important beyond money. They can provide personal satisfaction. Also, wages can only be paid if the company sells products. Product sales are directly related to customer acceptance. People will continue to purchase products only if they meet quality standards.

Understanding the relationship between job performance (quality work) and company success (ability to pay wages) is important. This challenge is addressed by quality assurance programs. These programs attempt to help all company employees realize the critical importance of quality work. The goal is to have all managers and workers develop an "I care about my work" attitude.



Fig. 19-18. Quality starts with product designs and extends all the way through the manufacture of an item. (Crouse-Hinds Div. of Cooper Industries)

Some management teams have attempted to promote this attitude with a **top down system**. Managers developed systems and handed them down to the workers. Typical of this system was the "Zero Defect" program. It was designed to have people produce products without defects. It and similar programs met only limited success. The workers were told the importance of quality. However, they were not involved in developing systems to produce quality products.

This shortcoming has been addressed with a new approach. This approach is called *quality circles*. A quality circle is a group of employees that meet to discuss quality issues. The group may include both managers and workers. However, in the circle, all people are equal. They have equal say and equal responsibility.

The quality circle, Fig. 19-19, usually meets one hour a week to:

- Discuss quality problems.
- Investigate causes for the problems.
- Recommend actions to solve the problems.
- Take corrective actions that will improve product quality.

Quality assurance programs are often designed with four major steps. These are:

1. Setting goals: This is measurable improvement in the level of quality. Quality control goals should be realistic, however. They should be



Fig. 19-19. This quality circle meets to explore ways to produce better products. (General Motors Corp.)

attainable within the company structure. The goals should be developed through cooperative worker-management action.

2. Encouraging quality work: This involves promotional media to reinforce the need for quality work and training to do quality work. See Fig. 19-20. Nothing should be left to chance. Workers should be shown how to do quality work.
3. Reporting progress toward quality goals: This involves maintaining records of product quality improvements. The records will identify quality successes and shortcomings. Records are the basis for corrective actions needed to improve product quality.
4. Recognizing and rewarding workers and departments who reach quality goals: All people appreciate a "well done" from fellow workers and from management. See Fig. 19-21.

INSPECTION

Even the right attitude will not guarantee that all parts and products will meet quality standards. Materials may have defects. Machines and tools may break. Workers may make mistakes. The results of these and other actions are bad products. They must be located and removed from the production line. This task belongs to inspection.

Specifically, inspection involves physically checking products against written specifications. These specifications are communicated by engineering drawings and specification sheets.

Inspection is a three-step system, Fig. 19-22. It involves:

1. Inspecting the product.
2. Reporting results.
3. Taking corrective actions.



Fig. 19-20. Workers must be reminded of the importance of quality. Note the slogan on the banner in this picture. (Ohio Art Co.)



Fig. 19-21. Workers who meet quality goals should be recognized. This group was recognized by a customer for meeting quality standards. (Federal Mogul Co.)



Fig. 19-22. Inspection involves determining quality standards, inspecting parts, reporting defects, and taking corrective actions. (AT&T Archives)

Inspecting the product

Inspection is done at all three stages of a product's life. These stages are shown in Fig. 19-23.

The first stage inspects materials as they arrive in the manufacturing plant. It is impossible to manufacture a quality product from materials that do not meet specifications. The quality of incoming materials is compared to the written specifications. Materials that pass this inspection enter the manufacturing system.

The second stage of inspection takes place during the materials processing activities. Parts are periodically inspected to ensure that they meet standards. Poor quality parts are removed from the line. It is important to remove bad parts before additional labor and machine time are invested in them.

Finally, the completed product is inspected. It must have an appropriate appearance and it must function properly. Products that pass this stage are packaged for delivery to the customer.

Proper inspection does not happen by chance. Inspection instruction should be developed. These instructions will insure that each product is properly inspected.

Inspection involves measuring and reporting product quality Fig. 19-24. Therefore, it involves measuring devices and reporting forms.

The simplest inspection uses human abilities. The inspector views the part and makes a judgment. This technique has little control and requires high skill.



Fig. 19-23. Inspection checks materials, work-in-process, and finished products. (Inland Steel Co. and Goodyear Tire and Rubber Co.)

Visual inspection is used for some surface finishes and product colors.

However, most inspection tasks use gages or other instruments. Simple inspection devices can be used to measure general specifications. These devices include go-no-gages, rules, micrometers, calipers and other distance or size measuring tools. Other properties are measured with more sophisticated devices including comparison microscopes, lasers, color spectrometers, radioactivity measuring instruments, and hardness testers.

Reporting the results

The results of an inspection must be recorded. Managers want to know several things including:

- Level of scrap. (This is the percentage of product that does not meet standards.)
- Types of errors.
- Sources of the errors. (These may be machines, molds, operators, etc.)
- Recommended corrective action.

This data is communicated through a number of forms. One is the **inspection tag**. This card, Fig. 19-25, is attached to the part. It tells managers what is wrong with the part and what to do with it. It may give rework directions or recommend scrapping.

The inspection activity is summarized on inspection reports. These may be for a shift (eight-hour period), week, or month. Inspection reports generally give the number of parts inspected, the number of rejects, and the reasons for the actions.

Corrective action

Inspection should cause at least two types of follow-up action. First, the manufacturing processes or system should be adjusted to reduce identified defects. This is a long-term corrective action. Secondly, the rejected parts should be considered. This may include:

- Reworking salvageable parts.
- Reclaiming usable materials.
- Scrapping waste materials and parts.

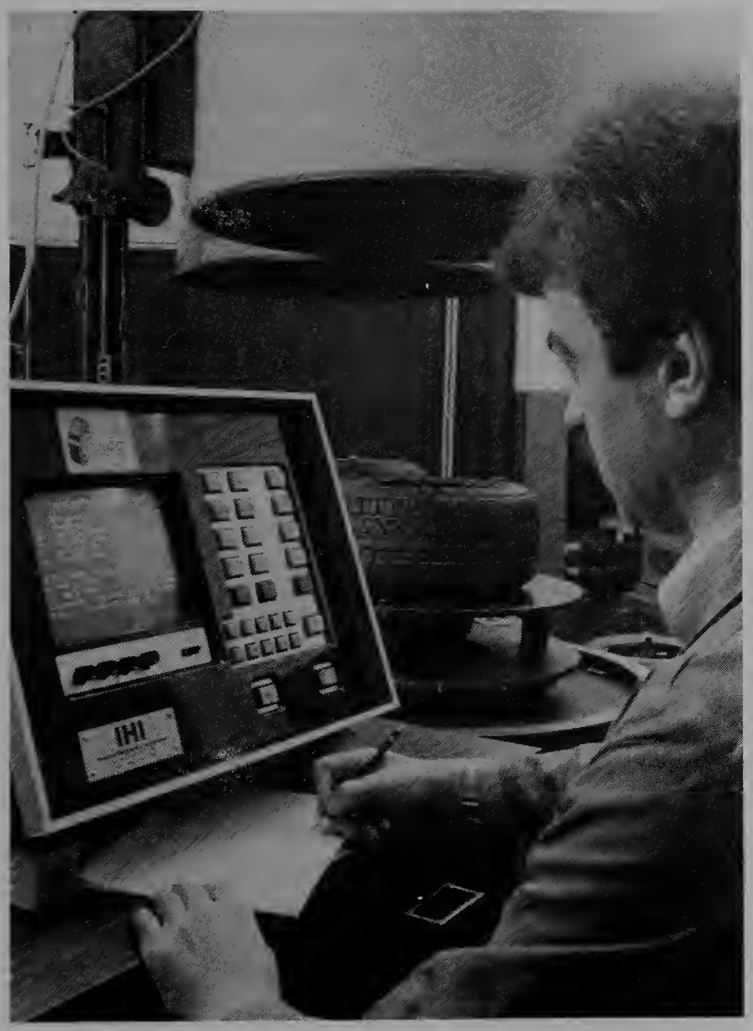


Fig. 19-24. This inspector is using laser holographs to inspect a high-performance radial tire. Note that he is completing an inspection report. (Goodyear Tire and Rubber Co.)



Fig. 19-25. Assorted inspection tags are shown here.

SUMMARY

Developing a manufacturing system involves several major actions. First, appropriate processes must be selected and placed in a logical sequence. Then the factory must be engineered. The plant must be arranged, and a material handling systems must be developed. Next, production tooling is designed, fabricated, and installed. These devices should increase the speed, accuracy, and safety of each operation. Finally, a system to maintain quality must be developed. It should include motivational and inspection components.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

branched layout
fixed path systems
flow process chart
inspection tag
material handling
material handling engineering
methods engineering
operation process chart
plant layout
processes layout
product layout
production tooling
quality control
top down system
variable path systems
world class product

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the four basic tasks involved in planning for manufacturing.
2. Name the five groups into which a flow process chart would be divided.
3. An operation process chart:
   a. Graphically shows all the operations and inspections needed to produce a product.
   b. Shows where the parts come together to form assemblies and products.
   c. Focuses on a single part.
   d. Both a and b.
4. Plant _____ involves the placement of machines and other equipment to promote the flow of people and materials.
5. _____ engineering involves designing and installing systems to move materials and products through the manufacturing plant.
6. Which of the following types of manufacturing systems use fixed path systems?
   a. Intermittent.
   b. Flexible.
   c. Continuous.
   d. Custom.
7. List the four categories of production tooling.
8. As related to manufacturing, quality means:
   a. Perfection.
   b. Meeting stated design standards.
   c. Freedom from defects.
   d. All of the above.
9. Name the two major thrusts of quality control in manufacturing.
10. _____ is physically checking products against written specifications.

APPLYING YOUR KNOWLEDGE

Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Develop a flow process chart for the base of the game shown in the activities for Chapter 1.
2. Develop an operation process chart for the trivet shown in the Applying Your Knowledge section in Chapter 9.
3. Design a poster that would encourage workers to strive for quality as they work.
4. Design an inspection gage to check the length of short slats for the trivet produced in Chapter 9.
   a. The gage should be designed to be easily made of a durable, yet inexpensive material.
   b. You can work alone or with a "team" of your classmates.
   c. Develop at least three rough sketches of different solutions.
   d. Select the best solution and make a refined sketch of it.
   e. Prepare a dimensioned orthographic sketch for the gage.
   f. Note: Be prepared to develop a set of procedures and develop a prototype using equipment available in your school laboratory.

20

CHAPTER

OBTAINING RESOURCES

After studying this chapter, you will be able to:
- *Describe the methods used to recruit and select good workers.*
- *Identify the three methods used to train workers for production jobs.*
- *List and describe the seven major steps involved in the purchasing system.*
- *Explain the differences among a purchase requisition, a quote and a bid.*

The product has been designed and engineered. Drawings and specifications are ready. A factory has been obtained. Manufacturing operations have been selected and grouped. Equipment has been arranged in a logical order; the material handling system is in place. An inspection system is ready for the product that will be manufactured. All that is needed for production to begin are two important resources: *people* and *materials*. See Fig. 20-1.

These two resources must be in place before products can be manufactured. They are obtained by entirely different systems. These systems are:
- Employment (often called "personnel").
- Material procurement.

DEVELOPING AN EFFICIENT WORK FORCE

An efficient **work force** is a vital resource for any enterprise. It must be developed with care, concern, and wise judgment. To develop a good work force, a structured system is needed. Management must:
- Recruit and select good workers.
- Develop new employees' abilities to do the assigned work.
- Promote safe work habits.

RECRUITING AND SELECTING WORKERS

For most companies, the process of hiring workers is a continuous one. Workers retire, quit, or are **fired** (their employment is terminated). Sales of existing products increase. New products are added. Together or by themselves, these actions can cause a shortage of workers. New employees must be recruited, selected, hired, and trained.

Hiring new workers is *serious business*. If employment practices are poor, the company will have a deficient work force. To avoid this pitfall, many companies use a **five-step employment process**, as shown in Fig. 20-2. First, the need for hiring new employees is established. Second, the job requirements are determined. Third, potential workers are

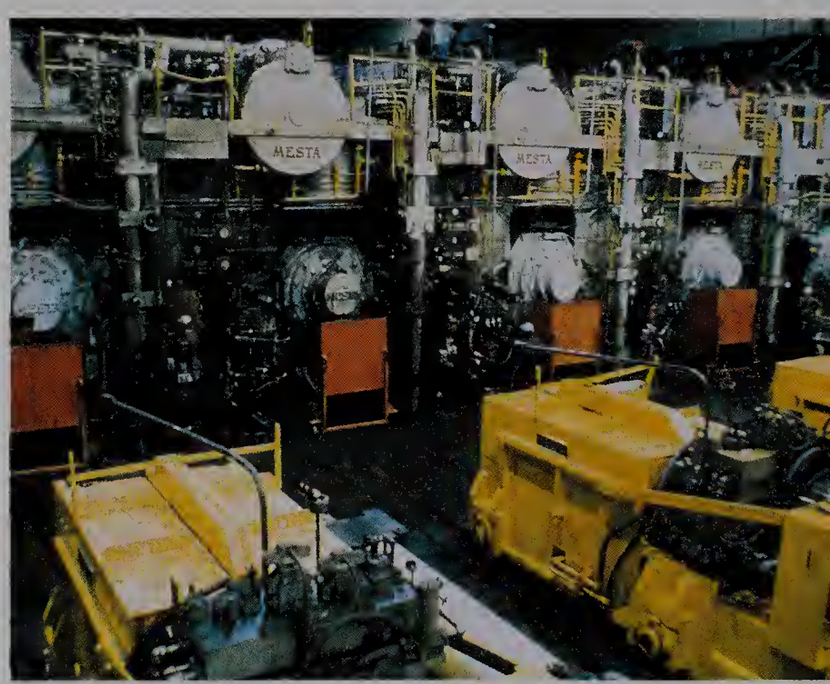


Fig. 20-1. The plant is ready for manufacturing to begin. All that is needed are people and materials. (American Iron and Steel Institute)

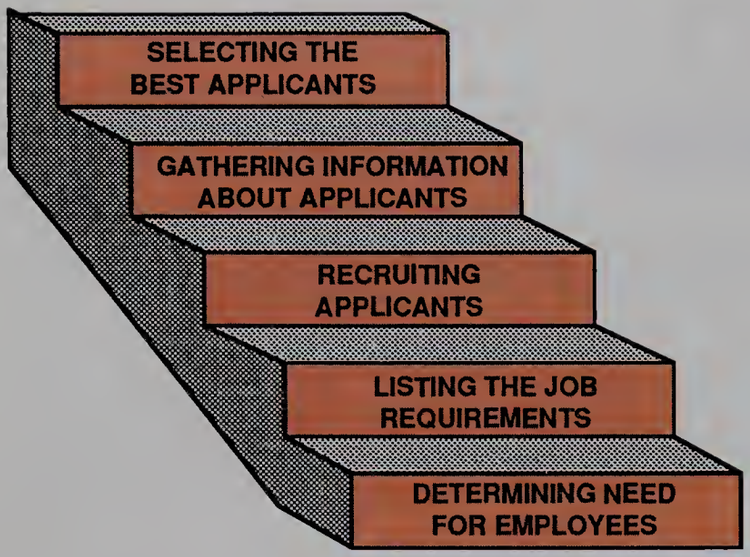


Fig. 20-2. The process of employing a new worker involves five major steps.

recruited. Fourth, information about applicants is gathered and reviewed. Finally, the best applicants are selected and offered employment.

Determining the need

The employment process begins with use of the *employee requisition form*, Fig. 20-3. This form allows a department head or supervisor to request hiring of a new or replacement worker.

The employee requisition form is the communication link between an area seeking a worker and the employment office. It tells employment personnel that a job opening exists. It lists the job title and briefly describes the duties and requirements.

Describing the job

Effective manufacture requires that each worker complete assigned tasks efficiently. *Job satisfaction* depends on workers being matched with challenging and rewarding jobs.

To meet these two challenges, employment officials must know the requirements for each job. Few jobs require the same human abilities. Some need high physical skill, while others call for problem-solving abilities. Some use artistic abilities, while others involve managerial skills. Look at the photos in Fig. 20-4. Can you list some of the skills or abilities each of the workers needs?

To help identify requirements for a job, companies prepare a written **job description**. See Fig. 20-5. This document usually includes:

- The title of the job.
- A description of the work to be done.
- Pay rate or wage group range.

A job description may also include:

- Minimum educational requirements.
- Personal abilities (leadership, responsibility, etc.) required.
- Specific skills needed.
- Previous experience required.

The job description serves as the foundation for the remaining steps of the employment process.

XYZ CORPORATION

PERSONNEL REQUISITION

Job title and classification:	**Salary range:**
Has this job been evaluated? ❑ **Yes** ❑ **No**	**This requisition is for** ❑ **New position** ❑ **Replacement**
Experience (In what fields? How many years?)	
Brief description of duties:	
To whom will the employee report?	**Date the job must be filled:**
Originator:	**Approved:**

Fig. 20-3. This typical employee requisition form was adapted from one used by Borg-Warner Corp.



A



B



C



D

Fig. 20-4. Study each picture. What skills do you think workers need for these jobs?. A–CAD operator (ARO Co.), B–Laboratory technician (Ball Corp.), C–Financial managers (American Assoc. of Blacks in Energy), D–Printing press operator (Graphic Arts Technical Foundation).

Recruiting applicants

The company must attract potential workers. People must be informed about job openings. They must be encouraged to seek employment. This process is called **recruitment.** The methods used to recruit workers will vary with the job, Fig. 20-6. Factory jobs and other positions for unskilled and semi-skilled workers are generally filled with walk-ins. These are people who come to the company seeking employment.

Skilled factory workers, office employees, and technicians often will come from vocational schools and technical institutes. These schools train people for *specific types* of jobs.

Managers, financial personnel, and salespeople may be recruited through advertisements in newspapers and specialized magazines. Young people with management, engineering, and other types of training are often sought at universities. They are recruited through job notices (special advertisements) and personal visits.

Experienced people to fill high-level positions are recruited though *employment* or *executive placement agencies*. These companies specialize in matching well-trained people with such positions. The agency collects a fee from the company or the new employee for filling or finding the job.

Recruiting advertisements. As you can see, advertisements are a recruiting tool for jobs at many levels. Good job advertisements are not easy to write, however. They must make a positive impression for both the company and the job. A good recruiting advertisement should:

- Attract attention.
    a. Start with an attention-grabbing headline.
    b. Follow with a good opening line.

XYZ CORPORATION
JOB DESCRIPTION

OCCUPATION NAME:	Assembler	**Occupation No.**	A-39-ACB
EFFECTIVE DATE: 2/9/xx	**ISSUE DATE:** 1/21/xx	**Wage Group No.**	A-6, B-4, C-8

JOB DESCRIPTION:

a. Perform assembling operations on bench or floor, such as bolting, riveting, or pinning companion parts together using any number or size of bolts, rivets, or pins. Involves the setting up of job and the use of either hand or power tools, such as air motors, electric drills, etc.

b. Perform assembling operations on bench, floor, fixture, or progressive line, such as aligning, fitting, and adjusting a number of parts requiring limits of less complicated nature than required in Class "C". Involves setting up the job and use of either hand or power tools, such as air motors, electric drills, etc.

c. Perform assembling operations on bench, floor, fixture, or progressive line requiring a maximum degree of accuracy to make accurate working alignments. Fitting and matching parts to a given specification of a complete unit or subassembly. Must be familiar with the required function of any unit assigned. May also require testing of the unit, ability to work from blueprints, sketches and specifications. Involves setting up the job and use of either hand or power tools, such as air motors, electric drills, etc.

Fig. 20-5. A typical job description, adapted from a form used by Carrier Corp.

TYPE OF POSITION	SOURCES OF JOB APPLICANTS
PRESIDENT VICE-PRESIDENT UPPER MANAGEMENT	• EXECUTIVE SEARCH (EMPLOYMENT) AGENCIES • ADVERTISEMENTS
SCIENTIFIC AND TECHNICAL	• UNIVERSITIES, TECHNICAL SCHOOLS • ADVERTISEMENTS • EMPLOYMENT AGENCIES
SKILLED WORKERS	• TRADE SCHOOLS • BUSINESS SCHOOLS • ADVERTISEMENTS • EMPLOYMENT AGENCIES • WALK-INS
SEMI-SKILLED WORKERS (MACHINE OPERATORS, INSPECTORS, ETC.)	• ADVERTISEMENTS • STATE EMPLOYMENT AGENCIES • WALK-INS
UNSKILLED WORKERS	• WALK-INS

Fig. 20-6. Sources of applicants for jobs at various levels in a company.

- Hold the reader's interest.
  a. Be written in a friendly, informal style.
  b. Be short.
  c. Describe the job and the type of person needed.
- Invite action.
  a. Tell the applicant how to apply for the job.
  b. Describe when and where to apply.

Gathering information

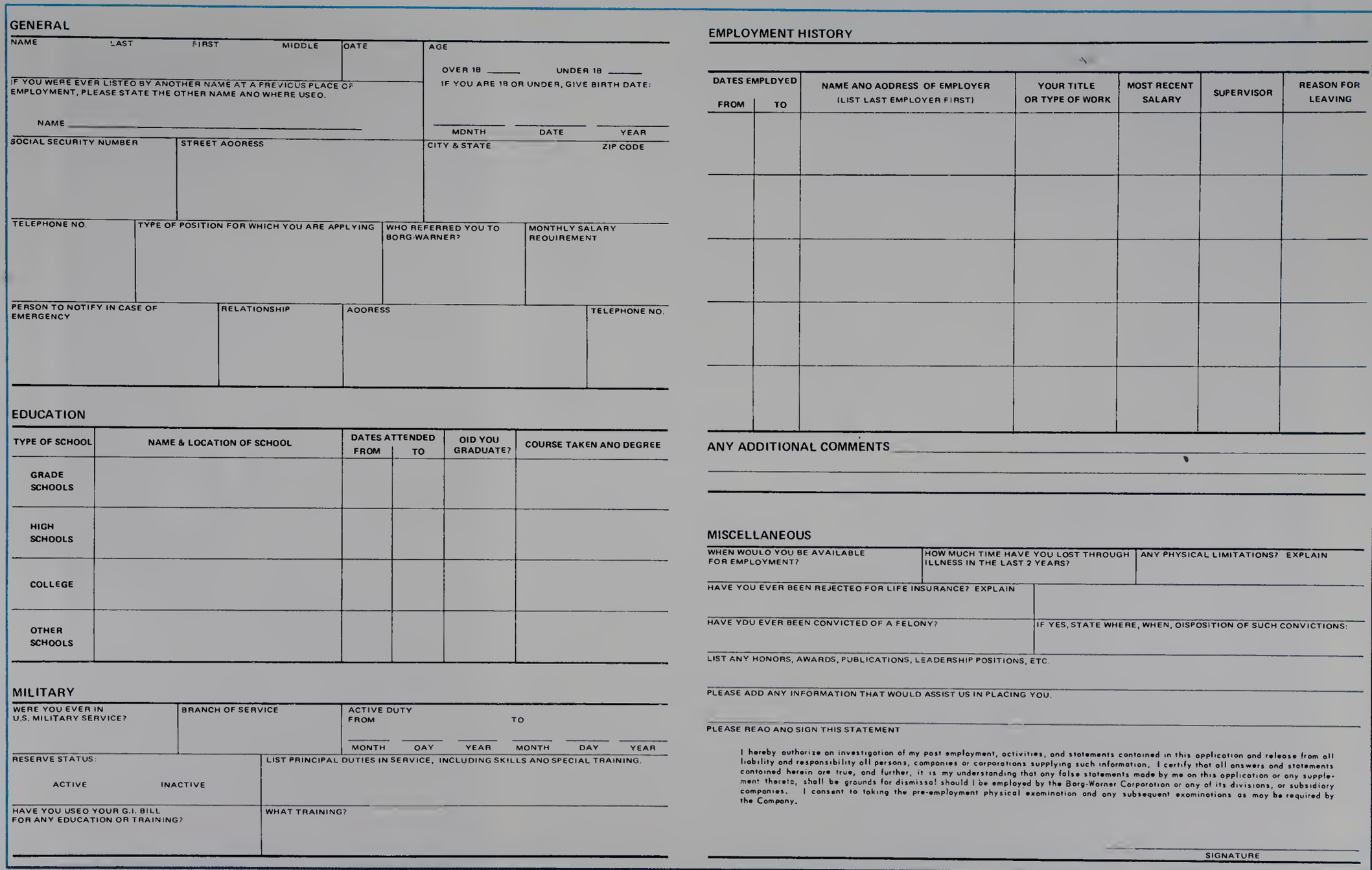
Good recruiting activities will bring in job applicants. These people may be from schools, responding to advertisements, or sent by employment agencies. Not all applicants will be suited for the job, however. The company must select the best people from the applicant pool. This requires *information*.

Typically, companies seek information about an applicant through four devices or sources. As shown in Fig. 20-7, these are:

- The application blank.
- Previous employers.
- The interview.
- Testing.



Fig. 20-7. Information about job applicants can be gathered from various sources.



GENERAL

NAME — LAST — FIRST — MIDDLE | DATE | AGE

OVER 18 _____ UNDER 18 _____

IF YOU WERE EVER LISTED BY ANOTHER NAME AT A PREVIOUS PLACE OF EMPLOYMENT, PLEASE STATE THE OTHER NAME AND WHERE USED.

NAME _____

IF YOU ARE 18 OR UNDER, GIVE BIRTH DATE:

MONTH _____ DATE _____ YEAR _____

SOCIAL SECURITY NUMBER | STREET ADDRESS | CITY & STATE | ZIP CODE

TELEPHONE NO. | TYPE OF POSITION FOR WHICH YOU ARE APPLYING | WHO REFERRED YOU TO BORG-WARNER? | MONTHLY SALARY REQUIREMENT

PERSON TO NOTIFY IN CASE OF EMERGENCY | RELATIONSHIP | ADDRESS | TELEPHONE NO.

EDUCATION

TYPE OF SCHOOL	NAME & LOCATION OF SCHOOL	DATES ATTENDED FROM	DATES ATTENDED TO	DID YOU GRADUATE?	COURSE TAKEN AND DEGREE
GRADE SCHOOLS					
HIGH SCHOOLS					
COLLEGE					
OTHER SCHOOLS					

MILITARY

WERE YOU EVER IN U.S. MILITARY SERVICE? | BRANCH OF SERVICE | ACTIVE DUTY FROM (MONTH, DAY, YEAR) TO (MONTH, DAY, YEAR)

RESERVE STATUS: ACTIVE INACTIVE | LIST PRINCIPAL DUTIES IN SERVICE, INCLUDING SKILLS AND SPECIAL TRAINING.

HAVE YOU USED YOUR G.I. BILL FOR ANY EDUCATION OR TRAINING? | WHAT TRAINING?

EMPLOYMENT HISTORY

DATES EMPLOYED FROM	DATES EMPLOYED TO	NAME AND ADDRESS OF EMPLOYER (LIST LAST EMPLOYER FIRST)	YOUR TITLE OR TYPE OF WORK	MOST RECENT SALARY	SUPERVISOR	REASON FOR LEAVING

ANY ADDITIONAL COMMENTS _____

MISCELLANEOUS

WHEN WOULD YOU BE AVAILABLE FOR EMPLOYMENT? | HOW MUCH TIME HAVE YOU LOST THROUGH ILLNESS IN THE LAST 2 YEARS? | ANY PHYSICAL LIMITATIONS? EXPLAIN

HAVE YOU EVER BEEN REJECTED FOR LIFE INSURANCE? EXPLAIN

HAVE YOU EVER BEEN CONVICTED OF A FELONY? | IF YES, STATE WHERE, WHEN, DISPOSITION OF SUCH CONVICTIONS:

LIST ANY HONORS, AWARDS, PUBLICATIONS, LEADERSHIP POSITIONS, ETC.

PLEASE ADD ANY INFORMATION THAT WOULD ASSIST US IN PLACING YOU.

PLEASE READ AND SIGN THIS STATEMENT

I hereby authorize an investigation of my past employment, activities, and statements contained in this application and release from all liability and responsibility all persons, companies or corporations supplying such information. I certify that all answers and statements contained herein are true, and further, it is my understanding that any false statements made by me on this application or any supplement thereto, shall be grounds for dismissal should I be employed by the Borg-Warner Corporation or any of its divisions, or subsidiary companies. I consent to taking the pre-employment physical examination and any subsequent examinations as may be required by the Company.

SIGNATURE _____

Fig. 20-8. A job application is used to gather factual and historical information about an applicant. (Borg-Warner Corp.)

The application blank, Fig. 20-8, is the basic tool used to screen job applicants for further consideration. The application blank is used to:

- Outline basic factual and historical information about the applicant.
- Provide an aid for the interviewer.
- Aid in training, promotion, and employment termination (firing) decisions.

Many companies use several *different* application blanks. One blank is used for factory workers, another for managerial and technical employees. Salespeople may complete still another form. However, all applications for employment will seek the following information:

- *Personal or general data:* name, address, telephone number, social security number.
- *Basic data needed for insurance purposes:* birth date, height, weight.
- *Educational data:* name and location of schools attended, dates entered and left, diplomas or degrees earned, areas of study.
- *Work experience:* names and addresses of previous employers, dates of employment, type of work, names of supervisors.
- *Personal references:* names and addresses of people who can describe the character and qualities of the applicant.

Once an application is complete, employment office personnel will review the information it contains. From the completed applications, they will make an initial selection of promising applicants for the position. They gather additional information about those passing this screening. Often, employment office personnel will contact the previous employer. They ask that employer about the applicant's work habits, commitment to the company, and ability to cooperate with supervisors and other employees.

The selected applicants usually will be interviewed by employment personnel or other managers, Fig. 20-9. A good interview serves two purposes. *First*, it allows the manager to form an opinion about the applicant. The manager will try to determine if the worker will fit into the company. *Second*, it allows the company to gain information that would be hard to gather in other ways. A face-to-face interview permits the manager to assess the applicant's ability to communicate and understand directions. The manager can also gain impressions about the person's drive, enthusiasm, tact, and desire to advance in the company.

In some cases, still more information is needed. *Testing* may need to be done for jobs that require special abilities. Assemblers may be given a dexterity test. Office workers may have to take a typing test. Designers may be given a creativity test. Factory workers may need to pass a blueprint reading test, Fig. 20-10. In every case, the test must *directly relate* to the person's ability to do the job. It may not be used to deny employment for reasons such as race, gender, or creed.

Selecting the applicant

The final step in the employment process is selecting the *best person* for the job. Managers and person-



Fig. 20-9. An interview can provide the additional information about a job applicant needed to make a wise employment decision. (Don Bauc, Thornridge High School)

nel officers must review all the information, then make a judgment. They select the applicant they think will be the best employee. The keys are *judgment* and *thought*. The final selection is a totally human decision. Such decisions are open to error. Mistakes are reduced, however, by objectively assessing information gathered during the employment process.

The person who is selected usually will receive a job notice from the company, Fig. 20-11. This form tells the new employee:

- That he or she is hired.
- The job to which he or she is assigned.
- The pay rate for the job.
- The date the job will start.

Inducting and training the new employee

Hiring the best applicants is the first step in developing an efficient work force. The new employees must then make the transition from being "outsiders" to being "insiders." They have a great deal to learn.

EMPLOYMENT NOTICE

NAME _____ CLOCK NUMBER _____

ADDRESS: _____ SOCIAL SECURITY NO. _____

EFFECTIVE DATE _____ TIME _____ AM PM

DEPARTMENT NAME _____ NUMBER _____

OCCUPATION _____

NEW EMPLOYEE ☐ REINSTATEMENT ☐ RATE _____ PER _____

EMPLOYEES SIGNATURE _____ DATE _____

FOREMAN _____ DATE _____

APPROVED _____ DATE _____

Fig. 20-11. Some companies use a formal job notice to inform new employees of their hiring, job assignment, and pay rate.

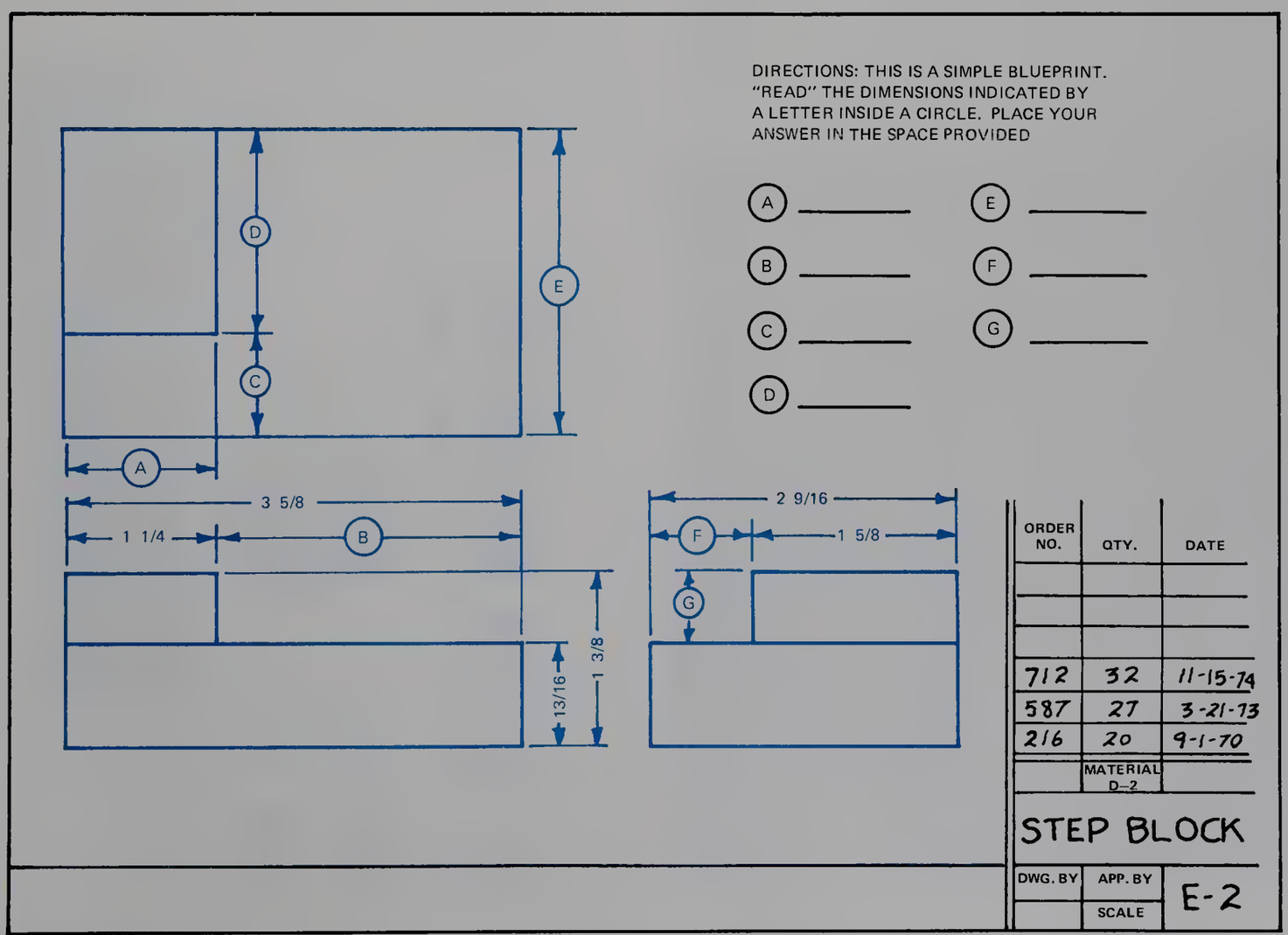


Fig. 20-10. This is one page from the blueprint reading test that a major manufacturer uses for prospective factory employees.

They need to know about the company. They also must learn about the specific job they will do. This involves *training*. Most companies conduct two types of training:

- Induction training.
- Job training.

Induction training

The first day on the job, a new employee may feel lost: the company is new, the work is unfamiliar, the people are strangers. *Properly orienting* new employees to the company is essential. The unfamiliar must be made familiar.

The way that the new employee becomes a part of the company will have a lasting effect on that person and on the enterprise. An easy adjustment into company routine may insure that the employee will be a satisfied worker and stay with the company. If the first days on the job are unhappy, though, the worker may leave the company at the earliest opportunity.

The process of introducing the company to a new employee is called induction training. It provides the new worker with information about the company and its general procedures. Often, the personnel (employment) office and the worker's supervisor divide this training between them. Induction training tasks may be divided as follows:

- Personnel department activities:
  a. Welcoming new employees to the company. This is often done by a top management official.
  b. Describing the company at a group orientation session. Its history and products are presented.
  c. Explaining work rules and policies. Usually, policies include those regarding attendance, absences, safety, security, and general conduct. This information may also be presented in the form of an employee handbook, Fig. 20-12. A copy of the handbook is normally given to each new worker.
  d. Giving information about various employee benefits and services. These often include insurance and retirement plans, profit-sharing or bonus programs, and recreational and social activities. Specific written information about these programs may be distributed.
- Supervisor activities.
  a. Explaining the essential elements of the job, methods to be used in learning the job, and related information to the new employee.
  b. Introducing him or her to other workers in the department. If there is a union, the worker is introduced to the union steward.
  c. Giving the new employee a tour of the work area. The tour includes lockers, time clock, rest rooms, and other essential facilities.

Job training

After completing induction training, most employees need specific job training. This training takes different forms, depending upon the type of work the person will do.

Production training. Production workers receive one of three types of training, Fig. 20-13. A method called *on-the-job training* is used for fairly simple and routine tasks. The worker develops the ability to do the job while working at the production line work station. Training is done by a fellow worker or a supervisor.

More complex jobs, where mistakes are costly, use *vestibule training*. The worker is given practical instruction away from the production line, often at a special training facility. This type of training is typically several days or weeks in length.



Fig. 20-12. Handbooks like these play an important part in induction training for new employees. (Ball Corp.)

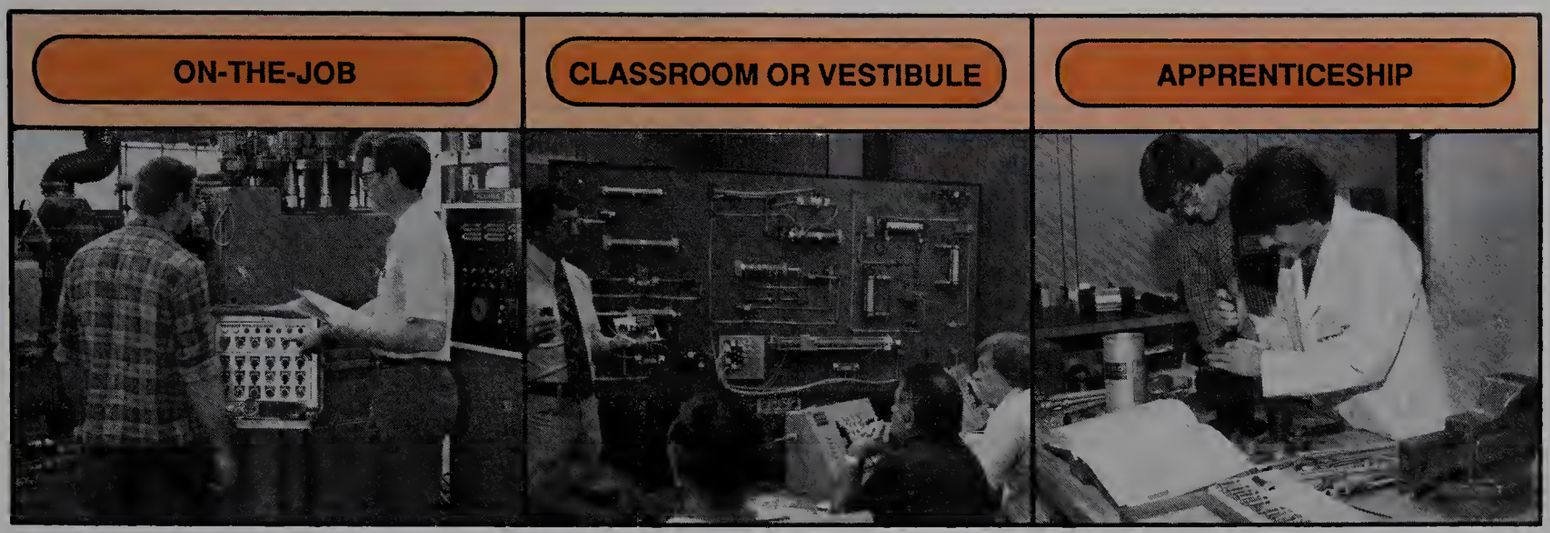


Fig. 20-13. The level of skills needed for a job determines which of these types of production worker training will be used. (ARO Corp.)

Apprenticeship is used to train machinists, millwrights, patternmakers, moldmakers, and other highly skilled workers. An apprenticeship is a four- to five-year-long training program. The employee works directly with a person who has mastered the job. In addition, she or he must spend a specific number of hours a week in theory classes. Many trades in the construction industry use this form of training.

The success of any type of training is depends greatly on the trainer. Not everyone who knows a job can train a new worker. A good trainer should:

- Understand the job.
- Be able to explain it clearly
- Be patient with the person trying to learn a new skill.

Employee development. Managers, salespeople, technical personnel, and other non-production employees must also be trained. This type of training is often called *executive* or *employee development*. Persons being trained may rotate through various jobs in an area; attend classes, workshops, and seminars, or enroll in university courses to develop their job skills.

Safety training

Being able to *do* a job is only part of the story. Each worker must also learn to do the job *safely*. See Fig. 20-14. Also see pages 10-13 of this text.

Working safely is not necessarily a natural thing. There is often a conflict between the *quickest* way get a job done and the *safest* way to do it. For example, crossing a street in the middle of the block may be the quickest way to get where you want to go. Walking to the corner and using the crosswalk is definitely safer. Only through continual training do we make it a *habit* to cross streets safely.

Job safety must be taught and then reinforced every day. Safety training should extend throughout each employee's working life. This training is part of a total *safety program*. As presented in Chapter 16, this involves engineering the job to be safe, educating (training) employees to work safely, encouraging all workers to use good safety practices, and enforcing safety rules.



Fig. 20-14. Proper work procedures and the correct equipment are important to worker safety on the job. Note that this machine operator is wearing hearing protection, safety glasses, and gloves. (UAW Solidarity)

The education or training aspect of a complete safety program involves four steps. As shown in Fig. 20-15, these are:

1. Tell the worker how to do the job safely.
2. Show the worker how to do the job safely.
3. Let the worker ask questions about procedures for doing the job safely.
4. Have the worker show that he or she can do the job safely.

The basic rule in safety training is to *NEVER assume a person knows how to do a job*. Always teach a worker the safe practices for each new job.

Safety training is often followed up with periodic safety meetings, use of posters and a safety booklet (Fig. 20-12), and giving awards for working safely.

MATERIAL PROCUREMENT PROCEDURES

The human resource is an absolute necessity for a manufacturing enterprise. *Materials* are also needed, Fig. 20-16. Materials, supplies, and utilities account for more than one-half the cost of operation for many manufacturing companies.

To operate efficiently, a company must obtain the right materials in the right quantity, to be delivered to the right place and time at the best price. Most manufacturing companies use a **purchasing system** to meet this goal. This system, as shown in Fig. 20-17, can be broken down into these major steps:

- Issue purchase requisition.
- Seek bids or quotes.
- Receive bids or quotes.
- Issue purchase order.
- Receive invoice .
- Complete receiving report.
- Make payment.

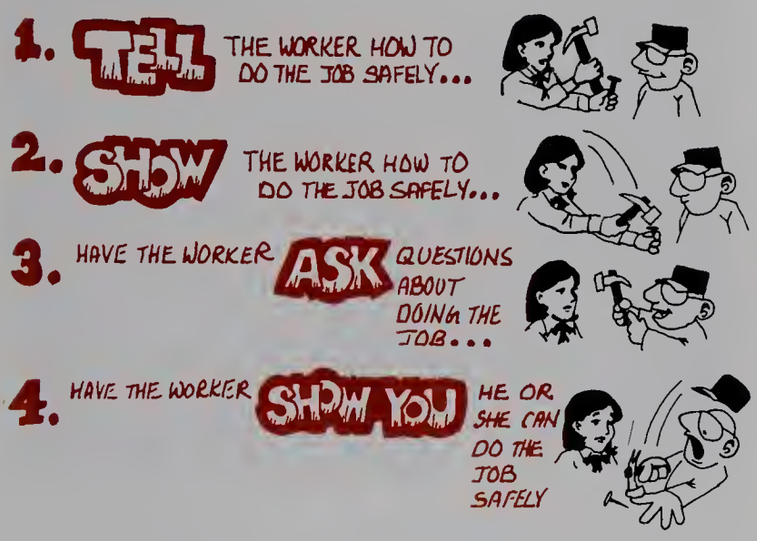


Fig. 20-15. The four steps used for effective safety training of a new or re-assigned worker.

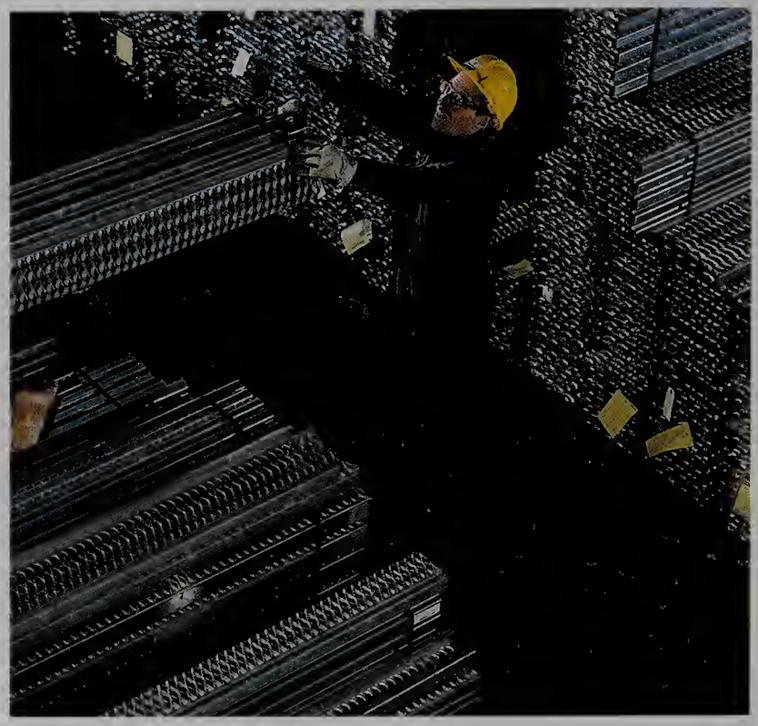


Fig. 20-16. Materials are a vital resource for manufacturing operations of all types. (Federal Industries)

PURCHASING FORM	PREPARED BY	SENT TO
PURCHASE REQUISITION	SUPERVISOR OF DEPARTMENT NEEDING ITEM	PURCHASING OFFICE
REQUEST FOR BID OR QUOTE	PURCHASING OFFICE	SEVERAL SUPPLIERS (VENDORS)
QUOTE OR BID	VENDORS	PURCHASING OFFICE
PURCHASE ORDER	PURCHASING OFFICE	VENDOR WITH BEST BID OR QUOTE
INVOICE (BILL)	VENDOR	ACCOUNTING OFFICE
RECEIVING REPORT	RECEIVING DEPARTMENT	PURCHASING AND ACCOUNTING
PAYMENT (CHECK)	ACCOUNTING	VENDOR

Fig. 20-17. The purchasing system used by most manufacturing enterprises involves these seven steps. For small or routine purchases, bids or quotes are seldom required.

ISSUE PURCHASE REQUISITION

A worker in a department that needs an item completes a purchase requisition, Fig. 20-18. The requisition contains vital information for the purchasing office. It includes:

- Materials needed (including catalog number, specifications, and quality requirement, if this information is appropriate).
- Quantity needed.
- Delivery date required.
- Delivery location (plant or department).

The requisition might tell the purchasing office, "*We need 1000 widgets by February 15. Buy them and have them delivered to Department 107.*"

The purchasing office carefully checks the requisition. If several departments want the same item, they may combine the orders to get a better price. They identify possible **vendors** (suppliers) for the items. Items that are inexpensive or frequently ordered are routinely purchased. The bidding process described below is not used for these items.

REQUEST BIDS OR QUOTES

Purchasing personnel must determine the price of the items they have been asked to buy. They send requests to major suppliers, asking for bids or quotes on the items. The form asks the supplier to provide a price for the desired materials or supplies. In short, the company is saying: "*We need 1000 widgets. How much will they cost?*"

A request for a **quote** asks the vendor to give the most recent price. This price, however, is not guaranteed. It may change between the time the quote was prepared and the actual purchase of the item. Catalog prices are a type of quote.

A **bid,** on the other hand, is *binding*. The vendor guarantees to honor the bid price for a specific period of time. After that time, a new bid is required.

RECEIVE BIDS OR QUOTES

The vendor returns the completed request for bid or quote to the purchasing office. It carries the message: "*You said you want to buy 1000 widgets. We will sell them to you for $1.25 each and will deliver them by February 15.*"

The purchasing office studies all bids and quotes to determine the best price for the items. The *best* price is not always the *lowest* price, however. The lowest-priced material is no bargain if it arrives two weeks late. The best supplier is the one who will deliver the desired material, when it is wanted, in the correct quantities, to the proper location.

ISSUE PURCHASE ORDER

A **purchase order** is a firm order for the materials. It says: "*We received your price quote for 1000 widgets. Send them to us by February 15 and we will pay the stated price.*"

The purchase order identifies the vendor chosen to provide the material. It states the kind and quantity


P.O. 1

BALL CORPORATION

DATE NO.

PURCHASE REQUISITION

PURCHASE FROM:	TERMS	ACCT. NO.
	F. O. B.	AFE NO.
	P. O.#	WORK ORDER NO.
	VENDOR NO.	DATE REQ'D.
DELIVER TO:	ROUTING	

QUANTITY	DESCRIPTION	UNIT PRICE	TOTAL

FOR	CHECKED BY	APPROVED BY

Fig. 20-18. A requisition tells the purchasing department what material is needed, in what quantity, as well as when and where it will be required. (Ball Corp.)

of materials ordered. The delivery location and delivery date are also given.

Several copies of the purchase order are usually prepared, Fig. 20-19. The vendor will receive one or two copies. One of these copies authorizes shipping of the items. The vendor returns the other copy immediately to acknowledge receipt of the order.

The other copies are used within the company. Typically, they are sent to:

- The accounting office, where the copy will be compared with the invoice (the customer's bill for the materials) when it is presented.
- The production department, to tell them that the materials have been ordered.
- The receiving department, to alert receiving personnel that the shipment is coming. The copy is also used to compare what is received with what was ordered.
- The purchasing department, where it is filed for reference in case of inquiries about the order.

RECEIVE INVOICE

The vendor performs two actions after receiving a purchase order. He fills the order and ships the materials to the specified location. At the same time, the vendor sends an **invoice** to the accounting office of the company making the purchase. The invoice tell that company: "*We received your order for 1000 widgets. They were shipped on February 1. You owe us $1,250 for the widgets, payable in 30 days.*"

COMPLETE RECEIVING REPORT

The materials shipped by the vendor will arrive on the receiving dock of the company that ordered them.

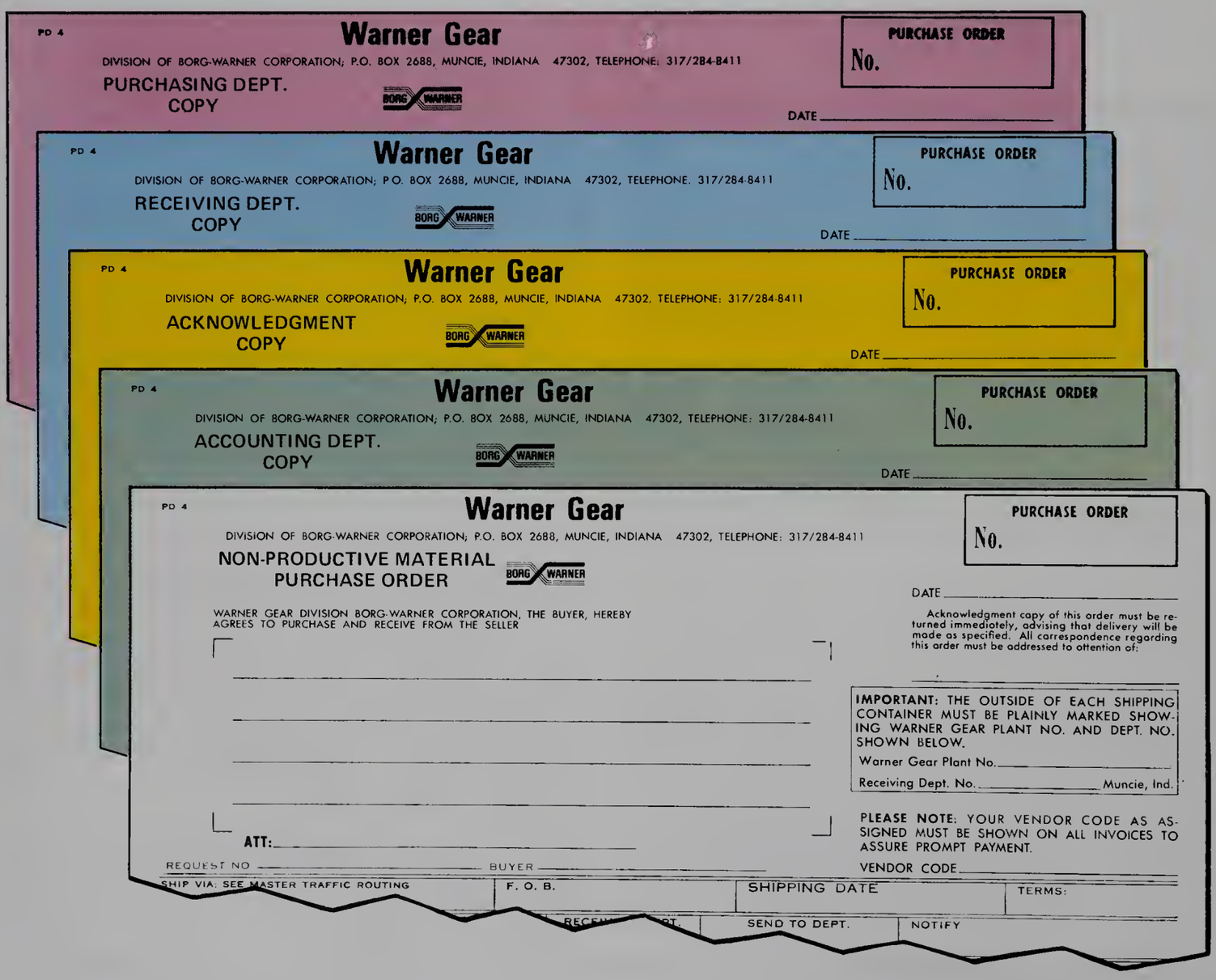


Fig. 20-19. In a large company's purchasing system, copies of the purchase order are sent to several departments. (Borg-Warner Corp.)

The personnel there will check the materials against a copy of the purchase order. If all the items are received, they will complete the **receiving report**. This usually involves signing their copy of the purchase order and forwarding it to the company's accounting office.

The receiving report says, in effect: "*We have received the 1000 widgets ordered on PO (purchase order) #107689. The order is complete and the items arrived in good condition.*"

MAKE PAYMENT

The invoice from the supplier says: "*We sent you the following items.*" The receiving report from the company's receiving dock says: "*We received the following items.*" If they match, the company owes the vendor money. Normally, it will be paid on the **due date**. This is 30 days from the date on the invoice.

The **payment terms** stated on the vendor's invoice often will allow the company to take a *2 percent discount* if they pay the bill in 10 days. This means that the company can subtract 2 percent from the amount they owe. If the invoice is for $1,250, the 2 percent **prompt payment discount** will be $25. If it takes advantage of the discount, the company will have to pay only $1,225.

This **payment** finishes the purchasing system cycle. People from a number of departments in the company were been involved. They may be located miles apart. Only the paperwork allows them to efficiently monitor their part of the system. Major companies repeat this cycle thousands of times each month.

SUMMARY

Human and material resources are vital to manufacturing. People use machines to change the form of materials. These people must be hired and trained. The best possible workers must be recruited and selected to meet the company's personnel needs. The new workers then must be trained complete assigned tasks efficiently and safely.

Material resources must be carefully purchased. The right material must arrive at the right time in the right location. These materials must be purchased at the best price.

Efficient employment and material procurement practices can save companies a great deal of money. Good workers produce products at lower cost. They contribute positively to the company's goals. They receive income and satisfaction from their work.

Likewise, an efficient purchasing system reduces material cost and avoids shortages. It saves money by having only enough materials of the right quality on hand when needed for manufacturing activities. It reduces or eliminates excess inventories storage of raw materials.

KEY WORDS

All the following words have been used in this chapter. Do you know their meanings?

bid
due date
fired
five-step employment process
invoice
job description
payment
payment terms
prompt payment discount
purchase order
purchasing system
quote
receiving report
recruitment
vendor
work force

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. What types of jobs are usually filled by "walk-ins"?
2. True or False? Testing must relate directly to an applicant's ability to do the job.
3. List and describe the three types of training used for production workers.
4. Besides understanding the job and being able to explain it to someone else, a good trainer must be _____.
5. Supply the missing words in the four safety training steps listed below.
   a. _____ the worker how to do the job safely.
   b. _____ the worker how to do the job safely.
   c. Let the worker _____about doing the job safely.
   d. Have the worker _____he or she can do the job safely.
6. Most companies use a purchasing system to obtain needed materials. Rearrange the list shown

below to place the purchasing system steps in the proper order:
Issue purchase order.
Receive invoice.
Seek bids or quotes.
Complete receiving report.
Receive bids or quotes.
Make payment.
Issue purchase requisition.

7. What is the difference between a bid and a quote?
8. The vendor's bill for material is called an _____.
9. True or False? The goal of the purchasing system is to always get the lowest price.
10. Vendors will often allow a discount if an invoice is paid in _____ days.

APPLYING YOUR KNOWLEDGE

1. Prepare a purchase order for the materials needed to produce the trivet described in the activities for separating processes (Chapter 9).
   a. Secure a catalog from your instructor. Several companies offer the types of material you will need.
   b. Look up the order numbers of the materials, using the catalog index.
   c. Check a bill of materials for the quantities needed.
   d. Place your information on a purchase order form similar to the one shown in Fig. 20-A.
   e. Be sure to use the catalog company's order number.
   f. Determine the cost of each item. (Lumber cost will be in either square feet or board feet.) Total the cost.
2. Visit a company personnel office. Ask about the company's recruiting practices and obtain an application blank. Share the information you obtained with the class.
3. Develop a newspaper advertisement to recruit a product designer for a student enterprise.

PURCHASE ORDER

TO: _____ FROM: _____

DATE: _____

CATALOG #	DESCRIPTION	QUANTITY	PRICE

TOTAL _____

Fig. 20-A. On a separate sheet of paper, make a purchase order form like this one for the materials needed to make the trivet.

21

CHAPTER

MANUFACTURING PRODUCTS

After studying this chapter, you will be able to:
- *Describe how routing, scheduling, dispatching, and expediting relate to production in manufacturing.*
- *Differentiate between pilot production and full-scale production.*
- *List major types of data that must be analyzed when controlling production activities.*

The manufacturing system is almost ready for the "acid test." Products are about ready to be produced. All resources are in place. Only three things need to be done. These tasks, as shown in Fig. 21-1, are:
- Scheduling production.
- Manufacturing products.
- Controlling production activities.

SCHEDULING PRODUCTION

Before production can begin, production managers must know what products are to be produced and how many are needed. This information is generated through production planning and control personnel. They have four main planning tasks to complete. These include:
- Routing: deciding where the work is to be done.
- Scheduling: deciding when the work is to be started and completed.
- Dispatching: issuing work orders to start actual production.
- Expediting: seeing that the work is progressing on schedule.

ROUTING

Routing work through the plant varies with the production system used. Continuous manufacturing

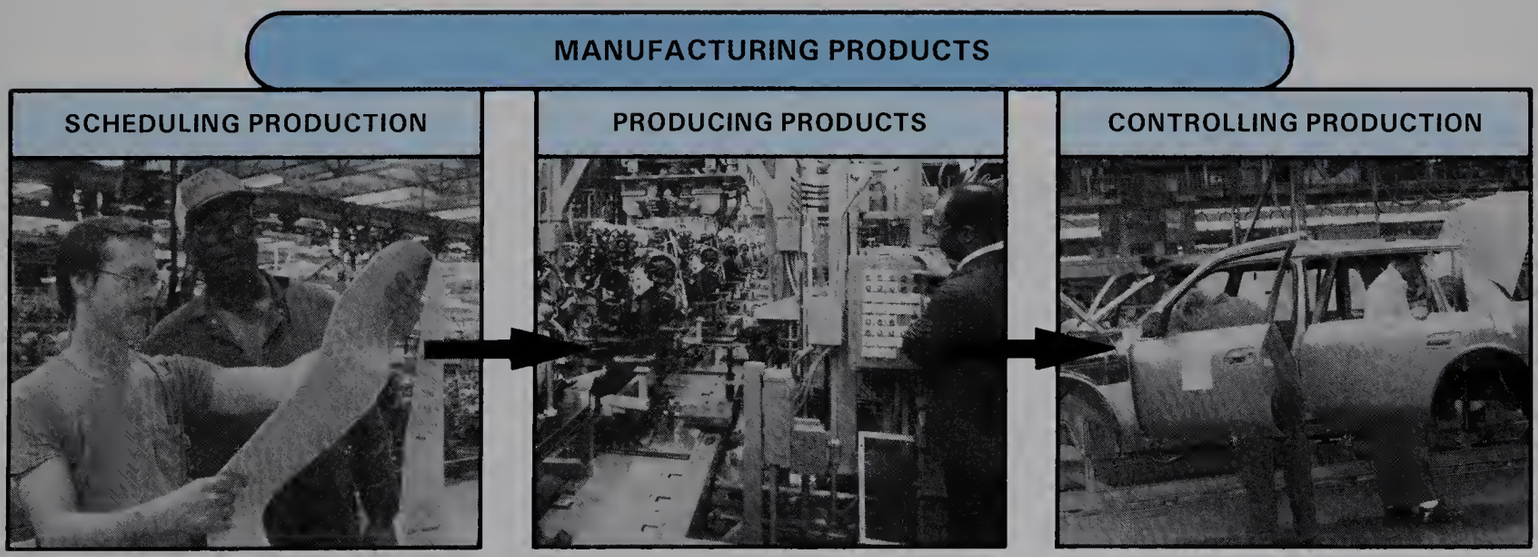


Fig. 21-1. Manufacturing products involves scheduling production, making products, and controlling the system. (Ford Motor Co.)

systems have routes built into the factory layout. The product moves along fixed paths from station to station. The routing is established when the plant is laid out for a specific product.

Intermittent and custom manufacturing offer a different challenge. The equipment is grouped by its function. For example, consider a roughing department in a wood furniture plant. It has all rough cutting and milling equipment in one area. Joinery equipment is in another area.



Fig. 21-2. Modern manufacturing companies use computers to help schedule production. (Crouse Hinds Div., Cooper Industries)

Production schedulers face a complex puzzle. They have limited equipment available. Each operation must be carefully scheduled. Assume the company is making wall shelves. The first operation may be cutting the material to length. The scheduler must identify a saw that can handle the job and determine when the saw will be available for use. Then a worker must be scheduled to operate the saw. Material handlers must be scheduled to move the lumber to and away from the saw. Inspection of the work must be scheduled. All of this scheduling must be done for one operation. It is repeated for every operation in the total process.

Scheduling requires a number of forms. **Work orders** direct machine operators. **Move orders** schedule all material movements in the plant. **Inspection orders** schedule quality control checks. Often, the planning process is called *form control* because forms control the system.

The use of computers, Fig. 21-2, has made scheduling easier. Forms are developed and stored in computers. Information is transmitted and updated with ease. However, production planning still takes constant attention.

The flow of materials and people must be continuously monitored. This flow is often shown on a **flow diagram**, Fig. 21-3. It may be an overlay on a plant layout drawing. The overlay shows the path each part

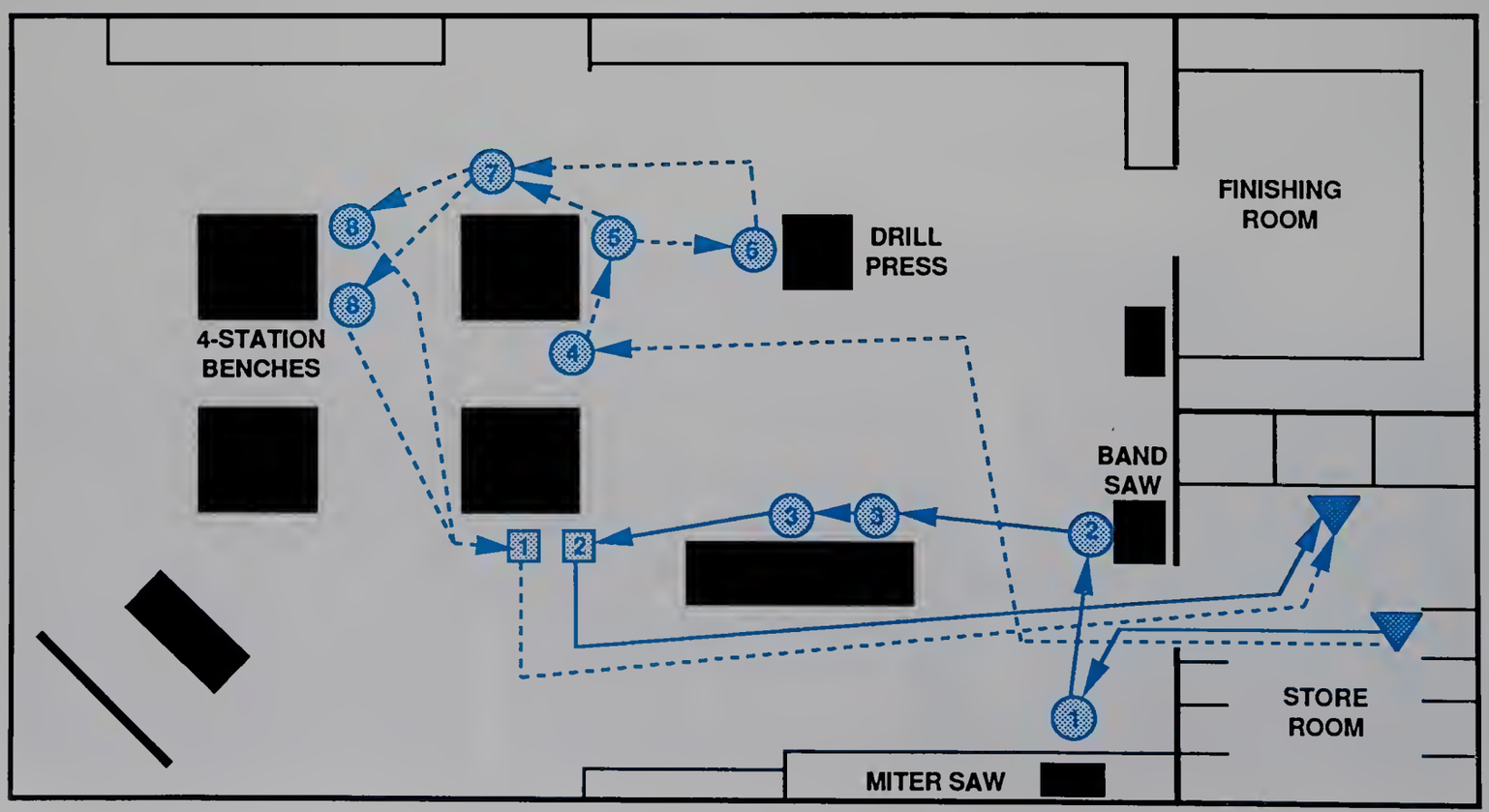


Fig. 21-3. Flow diagrams plot material movements on a plant layout drawing.

travels through the plant. It allows routing officials to avoid overloading single machines or areas of the factory.

In addition to material and people flow, managers must monitor total production schedules. Many companies summarize these schedules on a **line production routing sheet**. This form, shown in Fig. 21-4, summarizes basic information about each operation including:

- A description of the operation.
- The product rate in pieces per hour.
- The number of operators and machines needed.
- The cost of producing the product in standard units (usually 100 or 1000).

SCHEDULING

The information on the line production routing sheet is valuable in completing the next production planning step: scheduling.Scheduling involves balancing product demand with manufacturing capacity. Ideally, management wants 100 percent use of the manufacturing facility. This usually is not possible, but it is still the goal of production schedulers.

Schedulers base their work on certain data. This includes:

- Sales forecasts by day, week, and month for each product.
- Inventory levels for both raw materials and finished products.
- Manufacturing capacity to be scheduled in terms of the number of products that can be produced per hour or day.

Scheduling in continuous manufacturing converts sales forecasts into production schedules. The forecasted need for products must be assigned production days. Schedules determine the parts or products that should be manufactured each day the plant operates.

These decisions are based on present inventories of finished products and projected sales for the products. The schedule is communicated on a **production schedule**, Fig. 21-5. Production schedules must take into account **lead time**. This is the time between the

XYZ CORPORATION
LINE PRODUCTION ROUTING SHEET

PRODUCT: _____ DATE: _____

OPERATION NUMBER	DESCRIPTION	PRODUCTION RATE-PCS/HR.	NUMBER OF OPERATORS	NUMBER OF MACHINES	LABOR RATE $/HR.	COST PER 100 PARTS

Fig. 21-4. A line production routing sheet summarizes production activities.

XYZ CORPORATION
PRODUCTION SCHEDULE

PRODUCT NAME & NUMBER	PROJECTED SALES (A)	DESIRED END INVENTORY (B)	TOTAL REQUIRED (A + B = C)	BEGINNING INVENTORY (D)	TOTAL TO MAKE (C-D)	TO MAKE WEEK			
						1	2	3	4

Fig. 21-5. This is a sample production schedule form.

decision to make a product and the earliest time a product can be produced. Lead time is affected by the time it takes to:

1. Order and receive materials and parts that must be purchased.
2. Make parts from materials.
3. Assemble parts into products.
4. Package products for delivery.

All these factors must be considered when scheduling actual dates for each activity. See Fig. 21-6.

When properly developed, production schedules enable materials to be efficiently converted into products. They insure that products move through the factory and out the door in the least amount of time. They help improve the service provided to the customer. They also see that the right product is built at the right time, Fig. 21-7.

DISPATCHING

Dispatching is the act of telling plant-level management to build scheduled parts and products, Fig. 21-8. In continuous manufacturing, it involves releasing daily or weekly production schedules. Intermittent manufacturing is more complex. Individual work orders are released for each operation to be completed.

EXPEDITING

Once work has begun, it must be kept on schedule. This is when expediting or follow-up becomes necessary. Daily production reports are received in the production planning and control area. Controllers compare the production results with original plans. Corrective action is indicated if production is falling behind schedule. This action may involve working overtime, retraining workers, changing operations to improve efficiency, or holding a motivational meeting for production workers and management.

MANUFACTURING PRODUCTS

After products are scheduled, they must be produced. New products generally move through two types of production:

- Pilot production.
- Full-scale production.

PILOT PRODUCTION

High-volume consumer goods, like bicycles, toothpaste, tape recorders, and nails, are generally made on continuous production lines. Likewise, many parts for other products are made on continu-

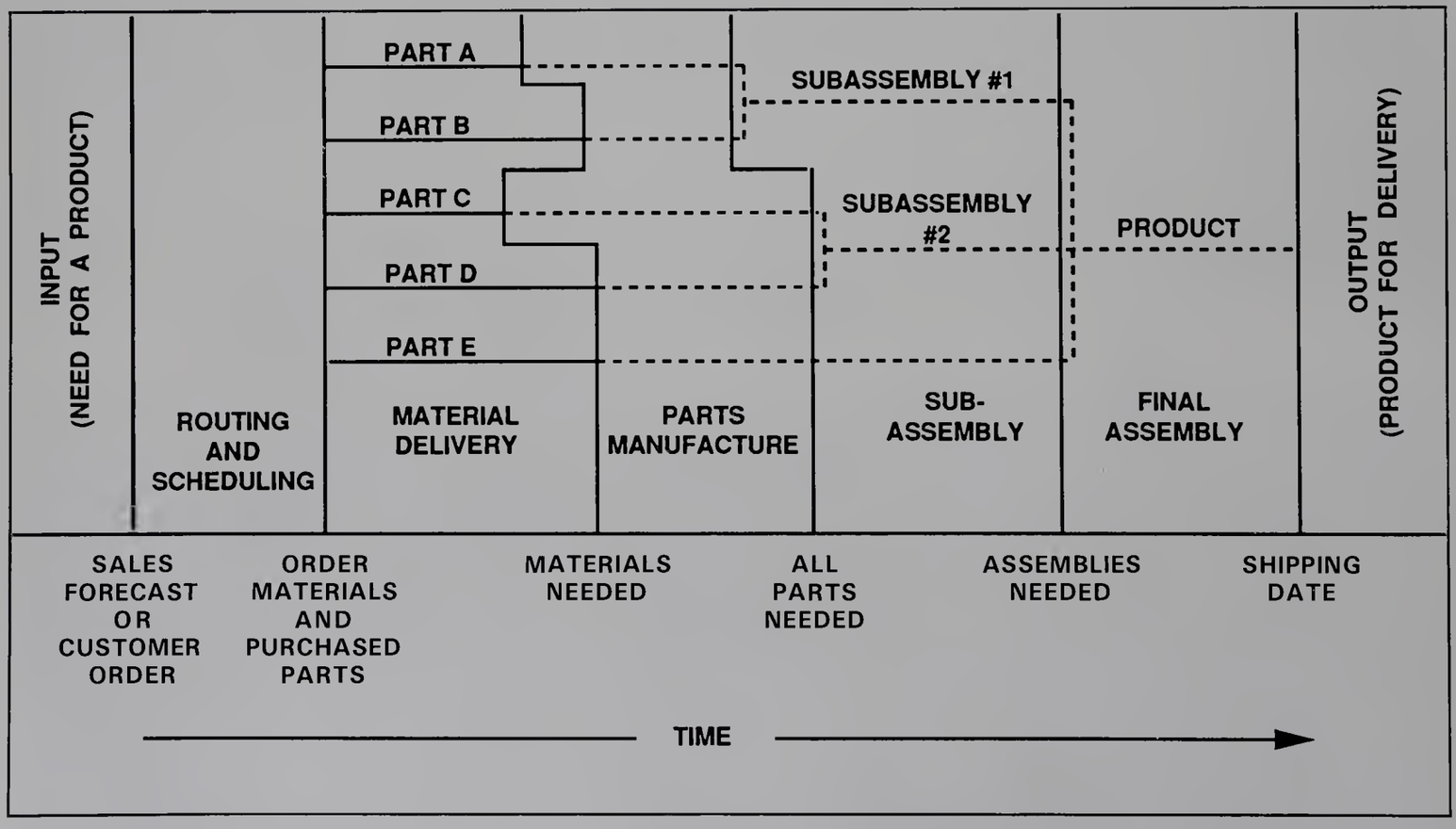


Fig. 21-6. This lead time diagram shows when different tasks must begin to support the production schedule. The space between lines represents time (days or weeks) needed to complete each task.

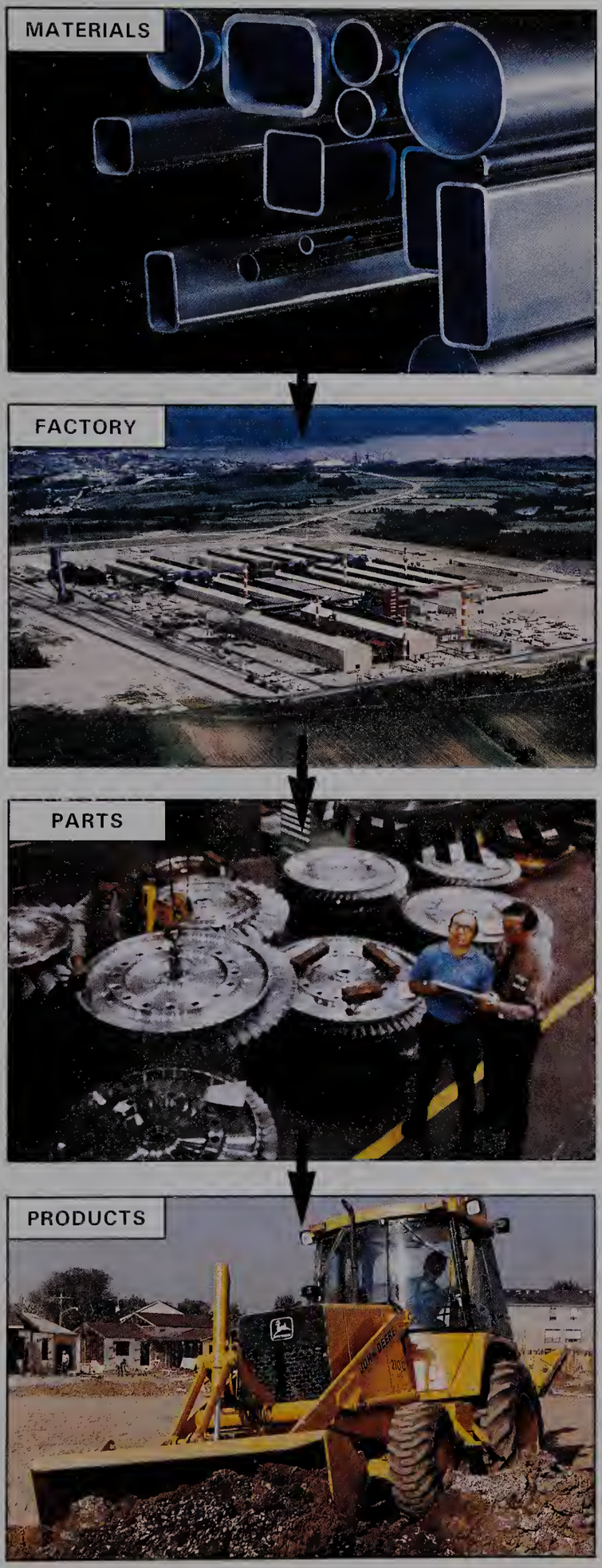


Fig. 21-7. Production scheduling moves materials through the plant to the customer.



Fig. 21-8. Production schedules are often dispatched to the factory floor by computers. (American Iron and Steel Institute)

ous lines. These lines are carefully designed. Manufacturing engineers develop the production methods. Industrial engineers complete the plant layout and material handling system. Quality control engineers develop the inspection system. However, this new manufacturing system may be untested. The engineers believe it will work, but the only way to know is to try it. Most manufacturers test new production lines before they are to begin full-scale production. This test is called a **pilot run**.

A pilot run is designed to identify problems in manufacturing systems and specific operations, Fig. 21-9. These flaws can then be corrected before too much time and materials are wasted.



Fig. 21-9. New processes must be pilot tested. This new process molds special fiberglass reinforced polyester into corrosion-resistant products. (Crouse-Hinds Div., Cooper Industries)

Typical corrections that may be required involve:

- Product designs.
- Tooling designs.
- Production methods.
- Plant layouts.
- Material handling systems.

Making changes

Any changes in a product design or in its manufacture must be approved and communicated. Changing a facet of the operation to solve one problem may cause additional problems if everyone is not informed of the change. For example, changing the product shape may make tooling unworkable. The product may no longer fit the package that was designed for it. Inspectors may reject the new parts unless they know about the change.

However, changes may be required. The product design may be changed to improve its function, or a new product design may be easier to manufacture. An **engineering change order** usually communicates these changes, Fig.21-10. The order indicates the type of change to be made and describes it in detail. It often lists the impact the change will have on toolings, operation charts, and inspection.

Changes in a product may require tool changes, or the pilot run may identify tooling devices that are not functioning properly. This may require another change order: a tooling change.

Likewise, production methods may be changed. The selection or sequence of the operations may need to be improved. Often, new flow process charts are developed. The new chart can be compared to the present methods, Fig. 21-11. Engineers can see if the proposed system reduces the number of operations, transportations, or delays.

All manufacturing systems have individual **workstations**. This is where each production worker completes his or her work. The arrangement of this station often can be improved. Industrial engineers use **operation analysis charts** to study individual operations. These charts help people analyze the physical arrangement of the tools, machines, supplies, and workpieces. See Fig. 21-12.

ECN No. 44835

DATE

ENGINEERING CHANGE NOTICE

ECN No 44835

MODEL (S)

SHEET OF

DESCRIPTION OF CHANGE ☐ NEW ISSUE ☐ SPEC. CHANGE ☐ PARTS LIST CHANGE ☐ OTHER | AFFECTS COST ☐ YES ☐ NO

DWG. NO.	CHANGE

REASON

TOOL CHG.		
CASTING	YES	NO
OPER. SHEET	CHG.	
	NO CHG.	
TOOLS	CHG.	
	NO CHG.	

DISTRIBUTION

B. P.	ECN	P.L.	DEPARTMENT
1	1		MFG. ENGINEERING
■	2		PROD. PLANNING
			PURCHASING
	1		INSPECTION
1	1		ASSEMBLY
■	1		COST
	2		SERVICE
1	1		FACTORY SUPT.
			ENGINEERING
			GUELPH

WHEN CHANGE IS TO GO INTO EFFECT

☐ AT ONCE – DO NOT USE UNCHANGED PARTS ☐ ISSUE EXISTING PARTS TO SERVICE ☐ SCRAP EXISTING PARTS ☐ REWORK EXISTING PARTS

☐ CHANGE PARTS IN PROCESS IMMEDIATELY – USE UP EXISTING PARTS

☐ NEXT LOT

☐ AS SOON AS POSSIBLE WITHOUT INTERRUPTING PRODUCTION

☐ ONE LOT ONLY

☐

REQUESTED BY	RR #	
ISSUED TO		
CHECKED BY		
LIAISON ENG.		
PROJECT ENG.		
APPROVED FOR ISSUE		

ECN No. 44835

Fig. 21-10. This is a sample of an engineering change order.

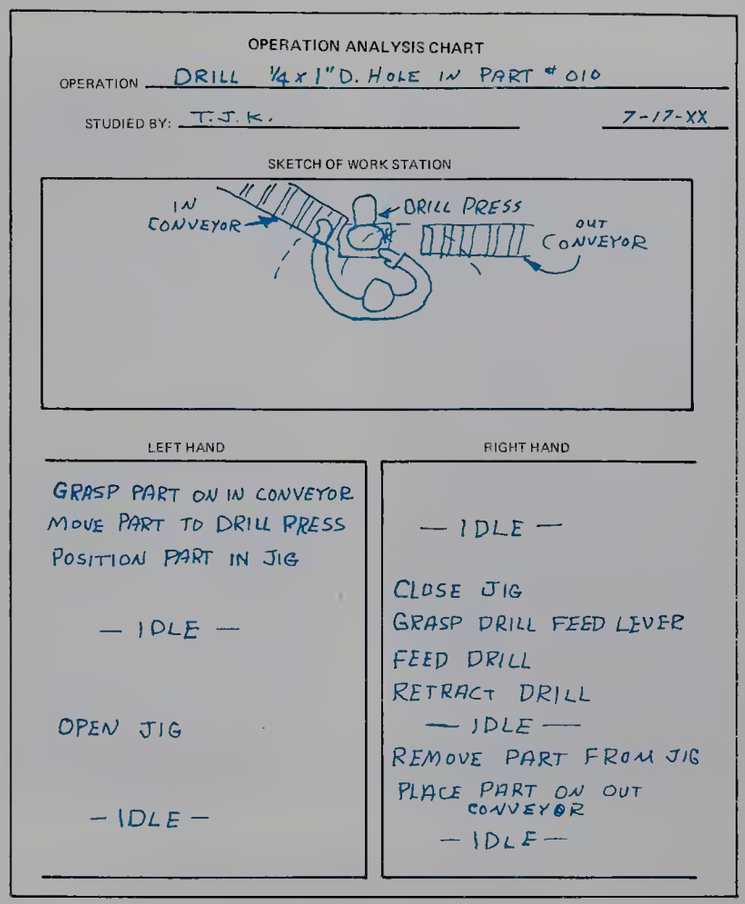
Finally, the pilot run may identify problems in the plant layout or material handling systems. The physical layout may cause problems in moving people and material through the factory. Also, the material handling system may not work properly, or it may damage the product.

FULL-SCALE PRODUCTION

The outcome of the pilot run and the changes it causes can result in a more efficient manufacturing system. Once the required changes are made, the system is ready for full-scale production. There may be some problems at first. New machines are operated by people who are developing new skills. Managers are directing the production of new products. As time passes, the system will run more smoothly. Efficient manufacturing will take place.

CONTROLLING PRODUCTION ACTIVITIES

How do you know if a manufacturing system is efficient? Efficiency must be measured. Information is gathered and analyzed to see if the system is



OPERATION ANALYSIS CHART

OPERATION: DRILL 1/4 x 1" D. HOLE IN PART # 010

STUDIED BY: T.J.K. 7-17-XX

SKETCH OF WORK STATION

LEFT HAND	RIGHT HAND
GRASP PART ON IN CONVEYOR	— IDLE —
MOVE PART TO DRILL PRESS	CLOSE JIG
POSITION PART IN JIG	GRASP DRILL FEED LEVER
— IDLE —	FEED DRILL
OPEN JIG	RETRACT DRILL
— IDLE —	— IDLE —
	REMOVE PART FROM JIG
	PLACE PART ON OUT CONVEYOR
	— IDLE —

Fig. 21-12. An operation analysis chart is used to study a specific operation or workstation to improve worker efficiency.

FLOW PROCESS CHART

☐ PRESENT METHOD ☐ PROPOSED METHOD

SUBJECT: SYSTEM OF PART FLOW AND INSPECTION 1332-027-003 AND 1332-027-005 IN DEPARTMENT N8

CHART BEGINS: LAST MACHINING OPERATION IN DEPT N8

CHART ENDS: LOAD IN TOTE BOX AFTER FINAL INSPECTION DEPT N8

SYMBOLS	DESCRIPTION	DISTANCE MOVED – FT.	TIME INVOLVED
○ ⇨ □ D ▽	EXCELLO OPERATION		
○ ⇨ □ D ▽	STACK IN WIRE BASKETS		
○ ⇨ □ D ▽	CONVEYOR TO WASH		
○ ⇨ □ D ▽	WASH		
○ ⇨ □ D ▽	CONVEYOR TO INSPECTION		
○ ⇨ □ D ▽	INSPECTION		
○ ⇨ □ D ▽	LOAD IN TOTE BOX		
○ ⇨ □ D ▽	WAIT FOR TRUCK		
○ ⇨ □ D ▽	TRUCK TO GRIND (SAME DEPT.)		
○ ⇨ □ D ▽	WAIT TO SYNCHRONIZE ON GRINDER		
○ ⇨ □ D ▽	GRIND		
○ ⇨ □ D ▽	CONVEYOR TO WASH		
○ ⇨ □ D ▽	WASH		
○ ⇨ □ D ▽	CONVEYOR TO INSPECTION		
○ ⇨ □ D ▽	INSPECTION		
○ ⇨ □ D ▽	STACK IN TOTE BOX		

FLOW PROCESS CHART

☐ PRESENT METHOD ☐ PROPOSED METHOD

SUBJECT: PART FLOW AND INSPECTION 1332-027-003 AND 1332-027-005 IN DEPARTMENT N8

CHART BEGINS: LAST MACHINING OPERATION IN DEPT. N8

CHART ENDS: LOAD IN TOTE BOX AFTER FINAL INSPECTION DEPT. N8

SYMBOLS	DESCRIPTION	DISTANCE MOVED – FT.	TIME INVOLVED
○ ⇨ □ D ▽	EXCELLO OPERATION		
○ ⇨ □ D ▽	OPERATOR STACK IN WIRE BASKETS		
○ ⇨ □ D ▽	WAIT FOR TRUCK		
○ ⇨ □ D ▽	TRUCK TO GRIND (SAME DEPT)		
○ ⇨ □ D ▽	WAIT TO SYNCHRONIZE ON GRINDER		
○ ⇨ □ D ▽	GRIND		
○ ⇨ □ D ▽	CONVEYOR TO WASH		
○ ⇨ □ D ▽	WASH		
○ ⇨ □ D ▽	CONVEYOR TO INSPECT		
○ ⇨ □ D ▽	INSPECTION		
○ ⇨ □ D ▽	STACK IN TOTE BOX		
○ ⇨ □ D ▽			
○ ⇨ □ D ▽			
○ ⇨ □ D ▽			
○ ⇨ □ D ▽			
○ ⇨ □ D ▽			

Fig. 21-11. These two flow process charts compare a manufacturing method (left) with a new proposed method (right). (Borg-Warner Corp.)

meeting goals. This information can be grouped into three major classes, as shown in Fig. 21-13:

- Production data.
- Inspection data.
- Payroll data.

PRODUCTION DATA

The most common source of manufacturing data is **daily production reports**, Fig. 21-14. On these reports, each department lists:

- The number of products scheduled to be built.
- The number of products started.
- The number of products scrapped.
- The number of products completed.

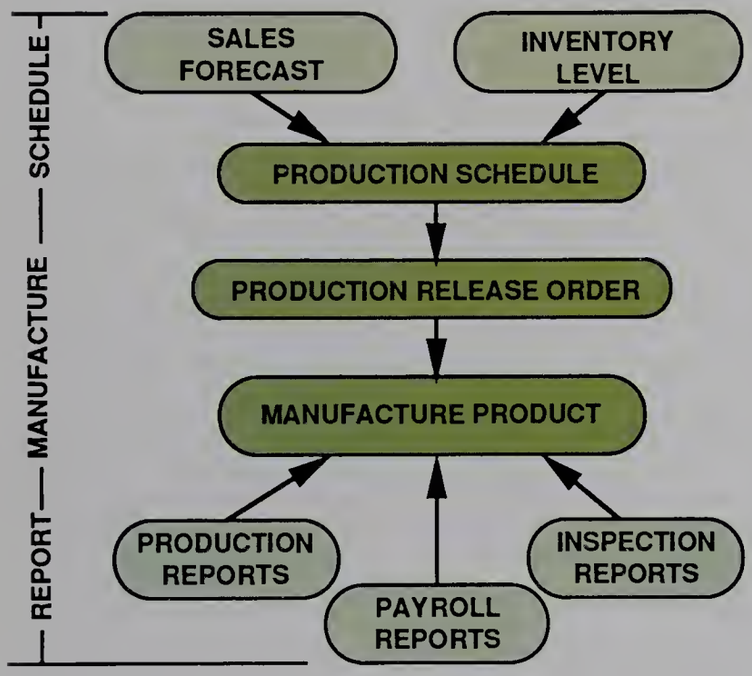


Fig. 21-13. Data flows from one area of manufacturing to another.

This data is compared to production schedules. If production is not meeting the schedule, corrective action may be required.

INSPECTION DATA

Inspectors also collect data during various stages of manufacturing. This data comes from three types of inspection, as shown in Fig. 21-15. These types of inspection include:

- Material inspection.
- In-work inspection.
- Finished product inspection.

Inspectors check materials as they enter the factory. They check that materials are of the proper size and quality. Other inspectors, or special electronic equipment, monitor parts and products as they move through the system. They identify and remove parts that do not meet quality standards. Their inspection reports list the number of parts rejects and the reasons for the rejects. See Fig. 21-16. This information helps identify recurring reject problems and indicates the need for corrective action. Finally, completed products are inspected before they are shipped to customers. Defective products are removed and repaired or scrapped.

PAYROLL DATA

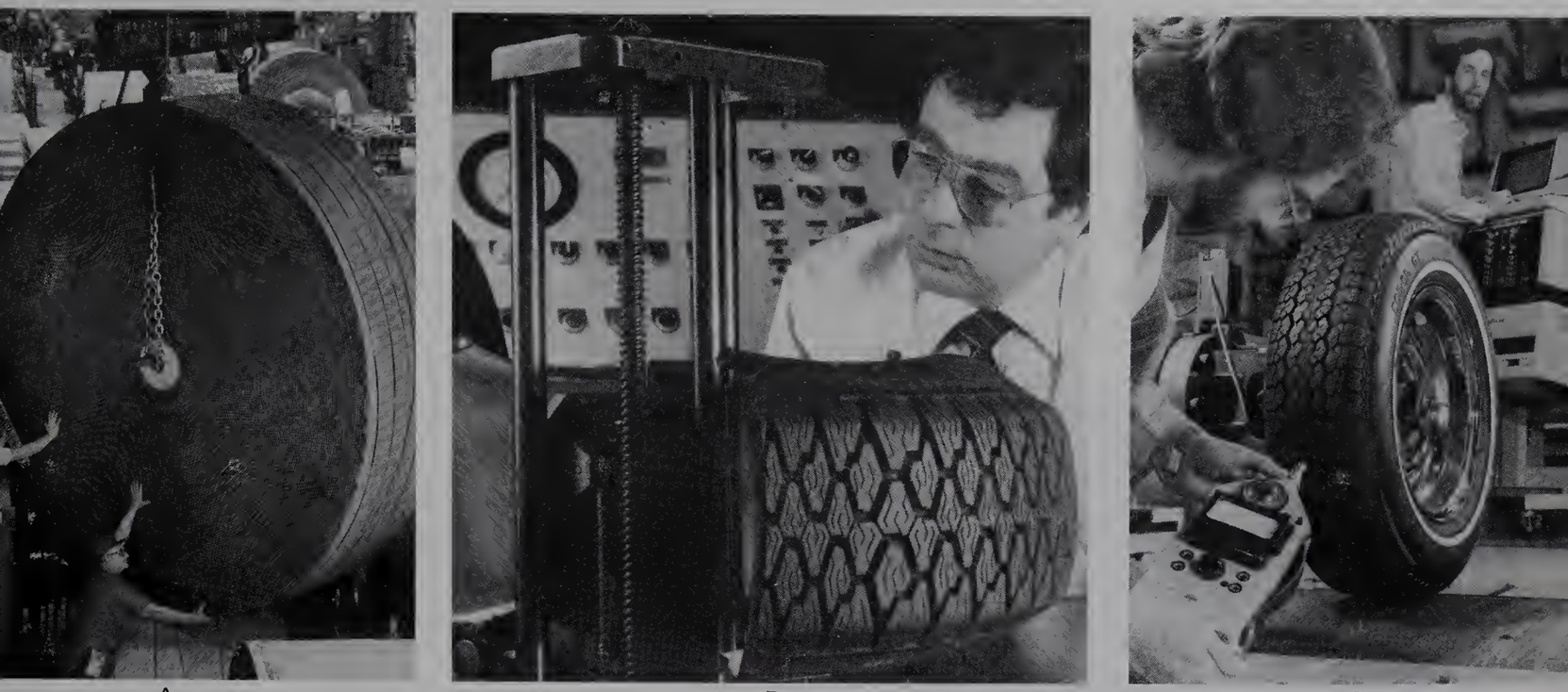
Another type of data collected is **payroll data**. Employees are paid for the work they do. Payroll data may be called *"time-on-the-job"* data. This information is generally gathered through the use of time cards and time clocks, Fig. 21-17. The cards are forwarded to the payroll office where total time worked for the pay period is calculated. Using this informa-

DAILY SCHEDULE AND PRODUCTION REPORT

DEPARTMENT: _____ DATE: _____

SCHEDULE			PRODUCTION			
PRODUCTION ORDER #	DESCRIPTION	NUMBER SCHEDULED	NUMBER PRODUCED	SCRAP AND LOSS	GOOD PRODUCTS	HOURS WORKED

Fig. 21-14. A form like this one could be used to report daily production results.



A B C

Fig. 21-15. Inspection takes place before, during, and after manufacturing. A–Materials are inspected before they can be placed on the production line. B–Parts are inspected during the manufacturing process. C–Products are inspected after manufacturing is completed. (Goodyear Tire and Rubber Co.)

INSPECTION REPORT

DATE: _____ **INSPECTOR:** _____

PART NO.	PASSED	WRONG SIZE	CHIPPED	IMPROPER SANDING	SCRATCHED OR DENTED	OTHER

Fig. 21-16. Inspectors may use a report similar to this one to report and communicate quality control information.

tion, paychecks are issued in keeping with the union contract or personnel policies.

In some cases, workers receive additional pay for completing work above set standards. This reward is called **incentive pay**. If a company has such a plan, production records for each worker or team must be maintained. These records must be collected, recorded, and summarized for pay purposes.

Some companies have **profit sharing**. This system allows each worker and manager to benefit from the overall efficiency and profitability of a plant or company. This payroll data is not derived from production information. Rather, it generally uses end-of-the-year financial data.

SERVICING PRODUCTS AND EQUIPMENT

Manufacturers have to be concerned with two activities somewhat removed from the making of products. These are:

- Servicing products once they are purchased and used by their customers.
- Maintaining equipment used in the manufacturing processes.

SERVICING

Every product has a life cycle. This is the amount of time that it provides useful service to its owner.

Most of the service activities involve repairers who fix broken products for their owners. However, manufacturers are concerned that their products are durable and give good service.

They take pains therefore to assure that:

- There are replacement parts available to repairers.
- Instruction manuals provide information on proper use and repair of products.
- Warranties provide replacement or free repair of products that do not live up to expectations.

Many manufacturers hire a staff to write technical manuals. Auto manufacturers are a good example. They provide shop manuals that detail service and repair for each model. They also ensure that there will be a plentiful supply of new repair parts. These parts must be available for many years after the year of manufacture.

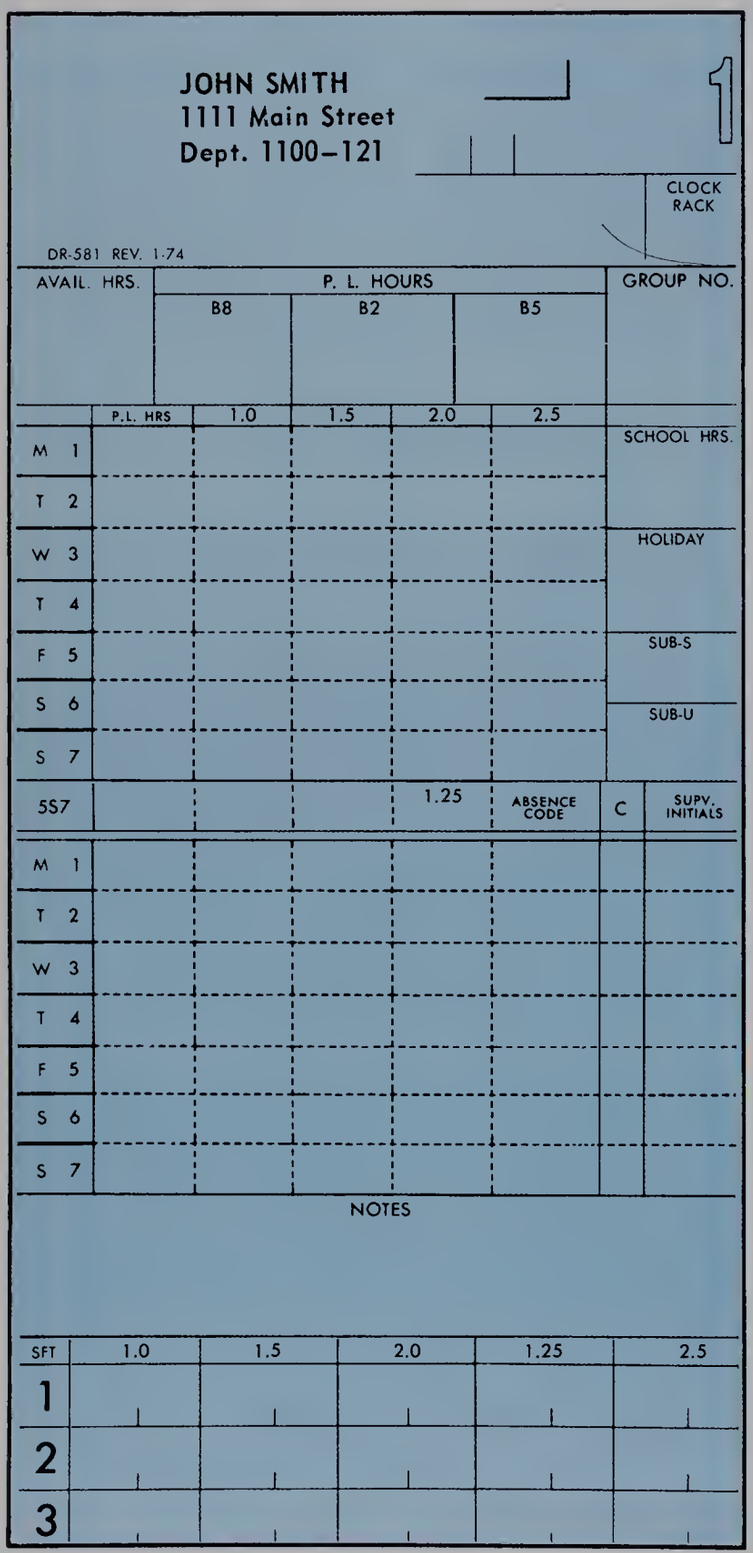

JOHN SMITH
1111 Main Street
Dept. 1100–121
1
CLOCK RACK
DR-581 REV. 1-74
AVAIL. HRS. | P. L. HOURS B8 B2 B5 | GROUP NO.
P.L. HRS 1.0 1.5 2.0 2.5
M 1
T 2
W 3
T 4
F 5
S 6
S 7
SCHOOL HRS.
HOLIDAY
SUB-S
SUB-U
5S7 1.25 ABSENCE CODE C SUPV. INITIALS
M 1
T 2
W 3
T 4
F 5
S 6
S 7
NOTES
SFT 1.0 1.5 2.0 1.25 2.5
1
2
3

Fig. 21-17. Time cards are often used to report payroll data. This typical time card has columns for straight time (1.0) and various overtime rates (1.5, 2.0, and 2.5).

MAINTENANCE

Maintaining plant equipment makes good sense. Maintenance means several things. First, equipment must be cared for as recommended by its manufacturer. Proper lubrication, for example, assures that a piece of equipment will continue to make quality parts for many years. Good maintenance is always cheaper than repairs, it seems.

Often, a company will hire a special maintenance staff to take care of its entire plant. On the other hand, there are companies that specialize in maintaining plants. They hire and train specialists. Then they contract to handle a customer's maintenances.

SUMMARY

Manufacturing is the act of efficiently producing scheduled parts, assemblies, and products. It involves integrating managerial and processing skills. This task is completed by scheduling production, manufacturing parts and products, and maintaining production records.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

daily production reports
engineering change order
flow diagram
incentive pay
inspection orders
lead time
line production routing sheet
move orders
operation analysis charts
payroll data
pilot run
production schedule
profit sharing
work orders
workstations

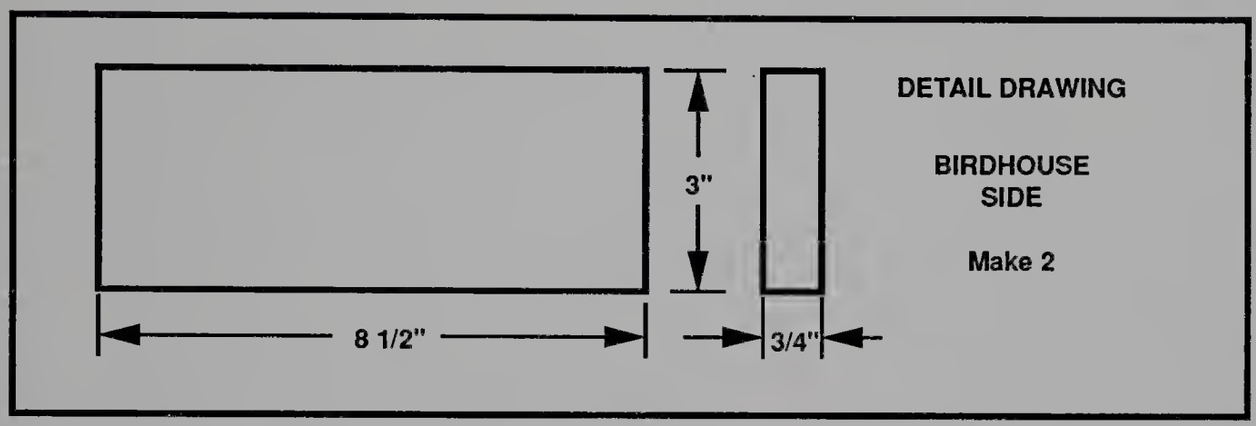
TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. _____ involves issuing work orders to start production.
2. List four factors that affect lead time.
3. Name three examples of how corrective action can be taken if production is falling behind schedule.
4. True or False? Full-scale production is used to test new production lines before they become pilot runs.
5. List three major types of data that must be analyzed when controlling production activities.
6. Name four types of data that might appear on a daily production report.

APPLYING YOUR KNOWLEDGE

1. Study the drawing and flow process chart shown in Fig. 21-A.
   a. This can be done individually or in groups of four or five.
   b. If working alone, list on a sheet of paper ways you think the manufacturing method could be improved.
   c. If working in groups, discuss the flow chart and any ideas advanced for improvement. Do not be afraid to give opinions. Industry



RECOMMENDED CHANGES

XYZ CORPORATION

FLOW PROCESS CHART

PRODUCT: # 101 Deluxe Birdhouse **PART:** Side

TASK	DESCRIPTION	DISTANCE	RATE
	Move to cut-off station.	5 feet	
	Cut part to length.		50 min/100
	Move to ripping station.	6 feet	
	Rip to width.		55 min/100
	Move to sanding.		
	Sand sides and edges.		95 min/100
	Move to inspection.		
	Inspect size and sanding.		20 min/100
	Move to storage.	20 feet	
	Store for assembly.		

Fig. 21-A. How would you improve the manufacturing methods for this part?

continually evaluates its procedures, looking for ways to improve production. Do not take criticism of an idea personally. Try to offer helpful suggestions that will make someone else's idea work.

d. If working in groups, have one member of each group act as a recorder. She or he will write down suggestions for improvement.
e. Compare suggestions with those of other groups.

2. Develop a form that can be used to gather inspection data for material entering the production line, work-in-process, and finished products. The data should be gathered every half hour during the production day.
3. Prepare a warranty card for a product of your choice.
   a. Be sure to indicate what is to be covered in the warranty.
   b. Specify the length of time the warranty will be honored.
   c. Write copy for the warranty and discuss it with your instructor.
4. Write up a plant maintenance schedule for your laboratory and its equipment. Hint: ask your instructor for a copy of the shop maintenance program or instructional manuals for the shop equipment.

22

CHAPTER

ORGANIZING LABOR UNIONS

After studying this chapter, you will be able to:

- *Describe ways in which unionization affects companies that are not unionized.*
- *Identify the major goals of organized labor.*
- *List and describe the nine steps involved in organizing a local union.*
- *Define the term "collective bargaining."*
- *Explain how labor and management use collective bargaining to reach an agreement.*
- *Describe the different roles played in labor negotiations by a conciliator, a mediator, and an arbitrator.*
- *Explain the operation of the grievance procedure.*

No study of manufacturing can be complete without exploring organized labor. In many manufacturing businesses, the work force is unionized. This is the case with most major companies especially in the steel, automotive, forest products (lumber, plywood, and paper), aluminum, and electrical products industries.

A labor union is the collective voice of its members. Unions pressure management to recognize and deal with workers' needs and wants, Fig. 22-1.

EFFECTS OF UNIONIZATION

Companies that are unionized directly or indirectly affect even nonunion companies. The **prevailing wages** and employee benefits in many areas are set by unionized companies. Workers tend to seek jobs where working conditions and pay are best. To attract workers, nonunion plants must offer pay rates and benefit packages comparable to unionized firms.

Union actions can directly affect the operations of nonunion companies. A **strike** (refusal to work) by the employees of a unionized company may prevent supplies from arriving at a nonunion plant.

In fact, a strike at a key industry will have a broad impact. A strike against the steel industry, for example, will cause material for tin cans to be in short supply. Automobile and appliance companies will find it hard to get enough sheet steel. Individual consumers will soon find products such as nails and screws are more costly and in short supply. During



Fig. 22-1. Members of different unions may join together to demonstrate unity on issues they feel strongly about. These union members in Pittsburgh, Pennsylvania, are protesting the use of nonunion labor on major building projects. (AFL-CIO)

long strikes, many products become scarce; almost everyone is affected in some way.

Union actions often directly influence management. Decisions made by managers are held up to review by workers. Such decisions may be challenged if the union feels they are against the contract or the employees' general welfare.

There is also a direct effect on managerial salaries. If a company's unionized workers get a wage increase, managers' salaries usually go up as well. This is almost always true for supervisory or factory floor managers.

Unions also have an impact upon government. Labor unions, like many groups, confer with elected officials. They suggest laws and courses of action that they feel will benefit their members. Also, most unions endorse and contribute funds to persons running for local, state, and national political offices. Union support can affect the results of an election.

You probably are not a union member. Members of your family may, or may not, be part of organized labor. All of our lives are affected by unions, though, in some way or at some time. Therefore, we must understand their organization, goals, and actions. This chapter will address:

- The goals of labor unions.
- How national and local unions interact.
- Steps needed to organize a local union.
- How a labor contract is negotiated.
- Grievance-handling procedures.

GOALS OF LABOR UNIONS

In a manufacturing plant, managers and workers must cooperate to produce products efficiently. Workers and managers have a common bond; they are part of the same enterprise. Their **job security** is directly related to how well the company is able to compete. They also know that they need each other. Managers bring certain skills and knowledge to the job. Factory and office workers bring other sets of human talents. Together, they can fulfill the company's human resource needs.

Workers and managers work to achieve the same goal: meeting the customer's needs by designing, engineering, producing, and marketing products. These two groups may not see the company from the same point of view, though. Their views may differ on various issues. The issues often involve major goals of the workers and their union. These include direct worker goals, Fig. 22-2, and broader political matters. For example, these aims and desires were listed in a recent booklet of the American Federation

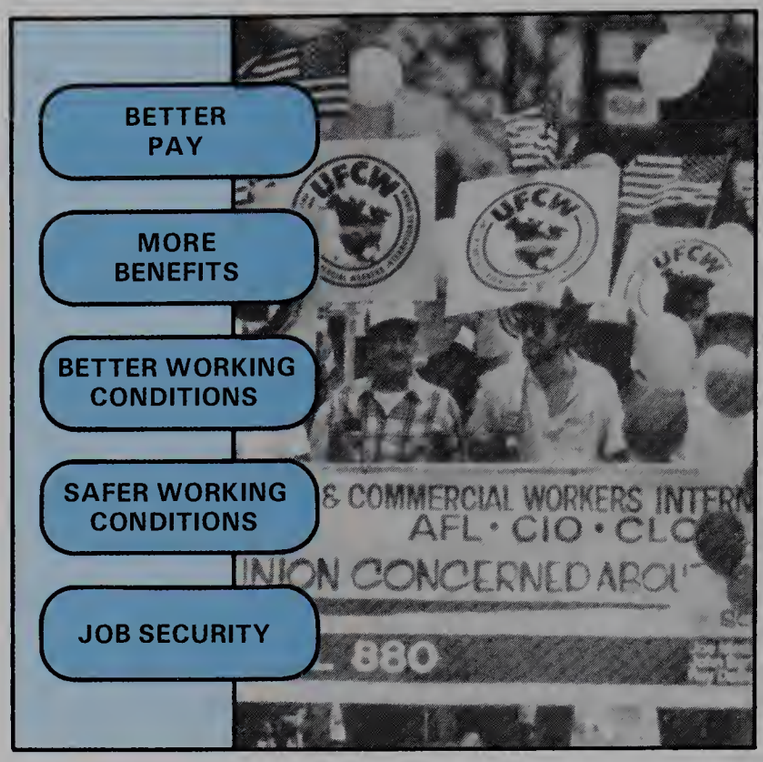


Fig. 22-2. Local unions help workers achieve goals like the ones listed above. (AFL-CIO)

of Labor and Congress of Industrial Organizations (AFL-CIO):

- To improve wages, hours, and working conditions for workers.
- To bring the benefits of collective bargaining to all workers.
- To achieve equality of opportunity for all workers.
- To support legislation that will aid workers, and oppose harmful legislation.
- To protect and strengthen democratic institutions and to preserve America's democratic tradition.
- To aid in promoting the cause of peace and freedom in the world.
- To protect the labor movement against corruption and racketeers.
- To safeguard the labor movement from communists, fascists, and other totalitarians.
- To encourage workers to register and vote, and to exercise fully their responsibilities as citizens.
- To encourage the sale of union-made goods through use of the union label.

LOCAL AND NATIONAL UNIONS

To carry out these aims, unions follow a specific organizational pattern. **Local unions** exist at the community or single plant level. **National unions** are made up of local unions (often referred to as "locals") across the country. An **international union** has locals in both Canada and the United States.

LOCAL UNIONS

The local union is the basic unit of a national or international union. The 90 national and international unions that make up the AFL-CIO have a total of over 60,000 local unions. These locals conduct day-to-day relations with management for over 14 million workers.

The national union has a great deal of control over its locals. It sees that each local lives up to the national union's constitution and to federal and state labor laws. On the other hand, the national union depends on the local union to obtain new members and collect dues. From the local, the national union also learns about workers' desires for political and economic action.

The local is organized along guidelines set by the national union. It usually has an executive board, president, vice-president, and secretary-treasurer, Fig. 22-3. In most locals, officers and board members work at their regular jobs. Sometimes, they are allowed time during the workday to conduct union business. Local officers also donate personal time to union duties. In larger locals of some unions, there may be a paid staff member to conduct daily business and handle money matters. Unions have different titles for such staff members. *Business agent* is common in the building trade unions; *financial secretary* also is widely used.

An important local official is the **union steward**, Fig. 22-4. Workers in a department or area elect their steward. He or she is the "first line" union representative in matters of working conditions, hours of employment, and wages. A steward's main duty is to represent workers on **grievance** matters (formal complaints over a manager's action such as discipline, overtime, layoff, or firing).

The local union often goes beyond labor/management activities to help meet the personal and social needs of its members. Locals often sponsor recreational, educational, and social programs, Fig. 22-5.

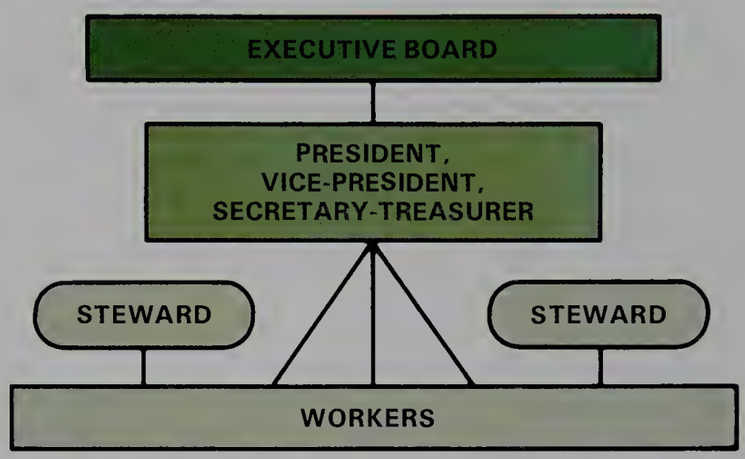


Fig. 22-4. Organization of a typical local union. Workers elect, and are represented by, the officers and executive board. The union stewards represent groups of workers in the plant.



Fig. 22-3. Elected officers conduct periodic meetings of the local union. (AFL-CIO)

NATIONAL UNIONS

National unions come in all sizes. The Teamsters, the Food and Commercial Workers, and the United Auto Workers (UAW) each have over 1,000,000 members. The American Federation of State, County, and Municipal Employees (AFSCME) also is over the million-member mark. Smaller unions include the International Typographical Union (for printers), the Transport Workers Union, and the International Brotherhood of Boilermakers. Each of these unions has fewer than 150,000 members. Even smaller national unions exist. Some have fewer than 100 members.

Unions also vary in the number of locals that make them up. The Postal Clerks Union has more than 6200 locals; the Pacific Log Scalers, fewer than 10.

The chief purposes of the national union are:

- To extend (enlarge) union membership and organization.
- To carry on collective bargaining at the national (industry-wide) level.
- To take part in federation activities (if the union is an affiliate of the AFL-CIO).
- To help locals bargain at the local (plant) level.
- To guide and monitor the actions of local unions.

Like the local unions, the national union has elected officials. It also has a paid staff. Elected officers are the president, one or more vice-presidents, and a secretary-treasurer. Staff members provide services through a number of departments and divisions, Fig. 22-6.

The national union holds a **convention** attended by **delegates** from its local unions, Fig. 22-7. These conventions, held annually or **biennially** (every other year), shape the policies that govern the national union. They also direct the actions of the national and local officers.

The officers must operate the national union in line with its **constitution**. This same document guides local union officers. In the final analysis, then, the local is a *reflection* of the national union.

LABOR FEDERATIONS

Early in the history of organized labor, national unions joined to form **federations**. Through these federations, unions could influence political change. Two major federations were the American Federation of Labor (AFL), founded in 1886, and the Congress of Industrial Organization (CIO). The CIO was formed in 1935. The two groups merged in 1955 to form the **AFL-CIO**.

Today, the AFL-CIO is the only major labor federation in the United States. Not *all* national unions belong to this federation, however. Some choose to remain *unaffiliated*.

The basic policies of the AFL-CIO are set at conventions held every two years. Representatives from each of the 90 affiliated unions attend. The





Fig. 22-5. Unions do more than negotiate contracts. They often sponsor educational programs and various types of social and recreational activities. (United Steelworkers of America)



Fig. 22-6. The organization chart for elected and staff officials of a major labor union. (Amalgamated Clothing and Textile Workers Union)

number of delegates each union can send is determined by on its size.

Between conventions, an Executive Council governs the AFL-CIO. This body is made up of the federation's president, secretary-treasurer, and about 35 vice-presidents. All of these officials are elected at the biennial convention. The Executive Council meets at least three times a year. It carries out policies and resolutions passed by the convention.

The AFL-CIO is primarily a support unit for its member unions. It has **political power**, rather than legal power. It depends almost entirely on how willing the affiliated unions are to cooperate.

The AFL-CIO's only *real* weapon is to **expel** (take away membership of) an affiliated union. It took such action in 1949-1950, expelling several unions dominated by members of the Communist Party. In 1957, it threw out the Teamsters Union for racketeering. The Teamsters were allowed to rejoin the federation in the late 1980s.

The AFL-CIO is usually unified by the strong common interests of its members. Unions have drawn together to try to reverse a decline in membership. Decreased union membership is due, in part, to the move from "blue collar" factory jobs to "white collar" service jobs. Also playing a part is the loss of jobs to developing nations and to countries located on the Pacific Rim.

ORGANIZING A LOCAL UNION

Management doesn't have to **bargain** with just *any* group. Workers who want a united voice must be recognized as an official union, Fig. 22-8. Federal law requires that an employer bargain in good faith with an officially recognized union.



Fig. 22-7. Delegates at union conventions establish policies to direct the operation of their labor organization. (United Steelworkers of America)



Fig. 22-8. Organizers help workers form an officially recognized labor union. (United Steelworkers of America)

Several federal laws protect the right of workers to form a union. The earliest was the Norris-LaGuardia Act of 1932. It outlawed "yellow dog" contracts that made workers agree not to join a union.

Under the **National Labor Relations Act of 1935** (also known as the Wagner Act), workers are guaranteed the right to:

- Organize or join a labor union.
- Bargain collectively with their employer.

The act also formed a new "watchdog" agency, the National Labor Relations Board (NLRB). This board's duties include:

- Preventing **unfair labor practices** that interfere with union-organizing activities.
- Insuring that collective bargaining takes place.
- Holding *representation* elections to decide which union, if any, the employees want to represent them in labor negotiations.

ORGANIZATION STEPS

The process of organizing a local union will vary from union to union and from company to company. As shown in Fig. 22-9, the normal union-organizing process involves nine steps:

1. Survey the company.
2. Form the plant committee.
3. Develop the promotional campaign.
4. Obtain authorization cards.
5. File the petition for election.
6. Hold the NLRB hearing.
7. Set the election date.
8. Hold the election.
9. Award certificate of representation.

Survey the company

Representatives from the national union, called **union organizers**, survey the company. They gather data about the company's earnings, officers and directors, suppliers, and customers. This gives the union a general understanding of the company. The data is also used to plan union organizing tactics.

Organizers will make the first contacts with workers outside the factory. These contacts are used to:

- Identify potential union leaders. These leaders can promote the organizing effort to workers who are not, at first, union supporters.
- Gather facts about workers' complaints and dissatisfaction.

Form the plant committee

The organizers will select pro-union employees to form the plant committee. That group's job is to promote the union to other workers. Since the organizers are employees of the national union, they are not likely to be allowed on company property. The plant is private property; non-employees can be kept out. As company employees, committee members are *expected* to be on company property.

Develop the promotional campaign

Organizing a local union is like conducting a political campaign. In both cases, the object is to win people's loyalties. To do so, union organizers must run an information campaign. There will be rallies,

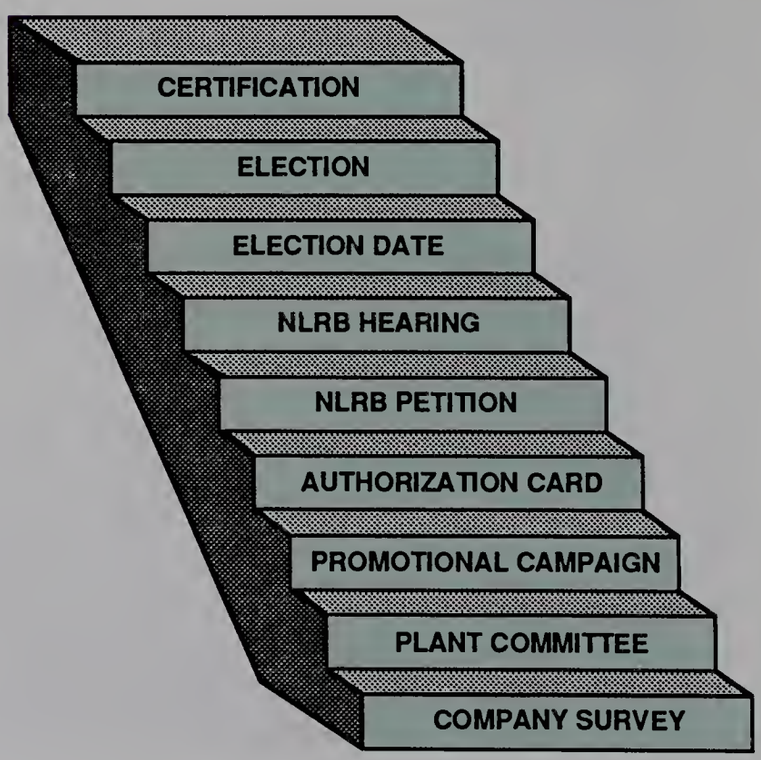


Fig. 22-9. The union organizing process usually involves these steps.

door-to-door home visits, and distribution of literature, Fig. 22-10.

Obtain authorization cards

The goal of the promotional campaign is to get employees to sign an authorization card, Fig. 22-11. This card gives the union power to bargain for the individual in "all matters of wages, hours, and working conditions."

File the petition for election

When the organizer has signed cards from at least 30% of the potential union members, he or she can ask the employer to recognize the union. If the employer refuses, the union can seek an election run by the National Labor Relations Board. To request an election, the union files an official NLRB form called a *petition*.



Fig. 22-10. Union organizers and pro-union workers pass out literature at a plant entrance. (AFL-CIO)

Hold the NLRB hearing

A field examiner of the NLRB will review the petition and other information. She or he will find out which workers the union wishes to represent and which will not be eligible to be members.

The **union contract** probably will not cover all the workers in a company. The *bargaining unit* may be just production workers, or it may consist of both production and office workers.

Managers (people who make hiring, firing, and discipline decisions) are *never* part of the union. Many "white collar" workers may be included, though. Accountants, engineers, and technicians are not members of management; thus, they too, may join the union.

Set the election date

When the examiner's work is done, a voting date is set. Notices are posted to inform workers of the coming election.

There is usually a great deal of activity in the period before the election. The union will campaign strongly for worker support; the company may advertise or use other means to persuade workers that a union is not in their best interest.

If either the union or management acts in an illegal manner, *unfair labor practice* charges can be filed.

AUTHORIZATION FOR REPRESENTATION BY
AMERICAN FEDERATION of LABOR and CONGRESS of INDUSTRIAL ORGANIZATIONS

I desire to be represented by a Union which is part of the AFL-CIO and I hereby designate the AFL-CIO and/or its appropriate affiliates as my Bargaining Agent in matters of wages, hours and other conditions of employment.

_____
Signature (Do not print.)

_____
Date

_____
Home Address—Street and Number

_____
City State Phone

I am employed by _____
Name of Company

_____ _____ _____
Job Title Shift Department

150

Fig. 22-11. If 30% of the employees sign an authorization card like this one, the union may ask the NLRB to conduct a representation election. (AFL-CIO)

An NLRB trial examiners will hear evidence and render a verdict.

Hold the election

An election supervised by the NLRB determines if the workers want a union, Fig. 22-12. Each eligible worker can vote for or against forming a local union. The union wins if it gets a simple majority of the ballots cast.

Award certificate of representation

If workers vote to form a local union, the National Labor Relations Board will award the union a **certificate of representation**. This will permit it to act as bargaining agent for the covered employees. The union can then officially organize the local, elect officers, and conduct union activities.

ELECTING LOCAL OFFICERS

Each local union has a set of bylaws. These cover topics such as the election and duties of officers, membership rules, dues, and the frequency and place of meetings. Local bylaws cannot conflict with the national union's constitution. If they *do*, the national constitution prevails.

Bylaws specify the *number* of officers for the local. There may be more, but most locals have at least these three:

- President.
- Vice-president.
- Secretary-treasurer.

Under federal law, these officers must be elected by *the local's* members, Fig. 22-13. Terms of office can be no more than three years. Officers can be elected to additional terms, though.

In some large locals, officers may become full-time employees of the union. It is more usual, however, for local union officers to remain employees of the company. They earn wages from the company for their work, just like other employees. They receive little or no pay for union duties, and often donate their time for union work.

The duties of officers vary from union to union. General duties of the positions include:

- President.
  a. Conduct all meetings of the local union.
  b. Appoint union local committees.
  c. Call special elections as needed.
- Vice-president.
  a. Assist the president in his or her duties.
  b. Take charge if the president should vacate the office.
- Secretary-treasurer.
  a. Keep minutes of all meetings.
  b. Receive dues.
  c. Keep accurate financial records.
  d. Pay union bills.

An important position in the local, as noted earlier, is that of union steward or **committeeman**. Stewards are not *officers* of the local. They are more like



Fig. 22-12. Workers vote in an NLRB-supervised election to determine if they want a union to represent them. (United Steelworkers of America.)



Fig. 22-13. Local union officers like this man are elected by fellow workers to terms of no more than three years. (United Steelworkers of America)

operating or line managers. They are the closest official to ordinary ("rank and file") union members, and represent them in disputes with the company. Stewards are part of the work force in the department or area they represent.

CONDUCTING LOCAL UNION MEETINGS

Local and national unions are democratic organizations. The members elect their leaders. In turn, these leaders hold meetings to inform members of issues and to gather information from them, Fig. 22-14. Each union has a suggested order of business for a local meeting. Locals of the International Association of Machinists use this one:

1. Pledge to the flag.
2. Roll call of officers and noting of absentees.
3. Report of committee on new applicants and on applications for membership.
4. Initiation of new members.
5. Reading and approval of minutes.
6. Introduction of visitors.
7. Reports of financial officer.
8. Reading of communications to local; reaction to communications.
9. Reports of committees.
10. Unfinished business.
11. New business.
12. Reports on sick and disabled members.
13. Report on unemployed members.
14. Adjournment.

A set of procedures is used to make the meeting run smoothly. These **parliamentary procedures** are recognized ways of running any meeting. They ensure that the right of all members to take part are recognized, Fig. 22-15. A list of common terms used in parliamentary procedure is given in Fig. 22-16.



Fig. 22-14. Union members make their views known to elected union leaders both at local meetings and at national conventions like this one. (United Steelworkers of America)

NEGOTIATING A CONTRACT

A union's major task is to negotiate a contract, or labor agreement, for its members. National unions



Fig. 22-15. Parliamentary procedure helps insure that rights of all members are protected. (United Steelworkers of America)

TERMS USED IN PARLIAMENTARY PROCEDURE

Adjourn — To end a meeting.
Agenda — A list of things to be done and discussed at a meeting.
Amend the motion — To change the wording of a motion that has been made.
Chair — The presiding officer at a meeting, such as the president or chairperson.
Debate — To speak for or against a motion. Every member has a right to debate an issue.
Majority — At least one more than half of the members present at the meeting.
Minutes — A written record of the business covered at a meeting.
Motion — A suggestion by a member that certain action be taken by the group.
Quorum — The number of members who must be present to legally conduct business at a meeting.
Second the motion — The approval of a motion by another member.
Table the question — To delay making a decision on a motion.
The floor — The right to speak in a meeting without interruption from others.
The question — The motion upon which members are called to vote.

Fig. 22-16. Knowing the terms of parliamentary procedure will help you participate effectively in group meetings.

often negotiate a contract with an entire industry or with a large company that has a number of plants. This contract covers the general issues facing all workers in that industry or company. The local union then will negotiate a contract to cover specific issues at the plant level. This extends the national contract into the local arena.

The act of negotiating is called **collective bargaining**. Its purpose is to bring about an agreement on wages, hours, and working conditions between management and the workers as a group.

COLLECTIVE BARGAINING

Collective bargaining is not a goal in itself. It is a process used by workers to achieve their goals of improved pay and working conditions.

Collective bargaining begins with union and company **negotiators** seeking compromise on basic issues, Fig. 22-17. The two sides do not necessarily want the same things. Collective bargaining seeks to find a middle ground that both can accept. In a successful compromise, neither side is seen as the winner or the loser.

Each side starts with its basic position on wages, hours, and working conditions. The other side meets each proposal with a counter-proposal. Various tactics are used to promote compromise. If management seems unyielding, the workers may *strike* (withdraw their labor from the company), as shown in Fig. 22-18. Lost production and reduced sales income may cause management to offer new proposals. On the other hand, the company may remain firm in its position. Management may wait to see if the loss of wages will cause the workers to soften their position.

The give-and-take of collective bargaining is sometimes aided by third parties. These parties may have the title of conciliator, mediator, or arbitrator. The differences among them lie in the role they play and legal power they have.

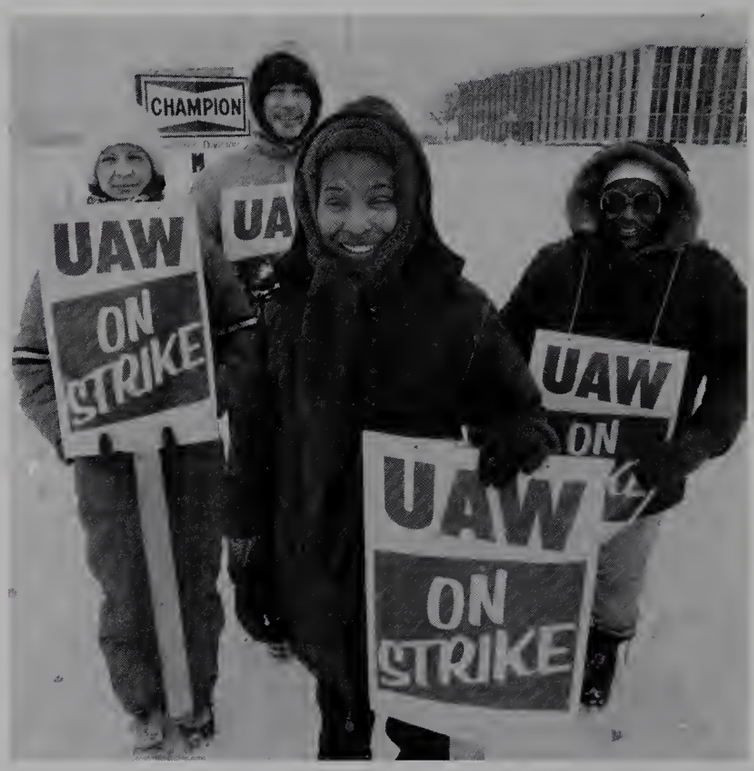


Fig. 22-18. Workers may strike to put pressure on management to agree to contract demands. (UAW Solidarity)



Fig. 22-17. Management and union officials meet in collective bargaining sessions to work out a labor agreement. (AFL-CIO)

A **conciliator** offers *no* opinion or solution. His or her task is to try to clear up the problem and help the parties reach agreement.

A **mediator** *recommends* a solution to the dispute. This recommendation is not binding–neither labor nor management must accept it.

An **arbitrator** is like a judge. She or he listens to both sides, then renders a *binding decision*. Both sides must accept that decision. Arbitration is seldom used in collective bargaining. It is widely accepted, though, as a means to settle grievances. That topic will be discussed later in this chapter.

Collective bargaining almost always ends with a labor agreement or *contract*. A typical contract will cover these topics in detail:

- Management prerogatives (rights).
  a. Lists the rights of management.
  b. Describes the areas of operation that cannot be questioned by the union, such as supervision of work, production schedules, and managing the business.
- Bargaining unit recognition and membership.
  a. Lists the types of workers to be included in the union.
  b. Describes the level of union security:

Union shop: Workers must join the union after a probationary period, usually 30 days. Union members get full contract protection after a set period. Most often, this period is 90 days.

Open shop: Both union and nonunion employees are hired. Nonunion members do not have to join the union or pay dues to support its activities.

Closed shop: Workers must be union members before they can be hired. This type of union was made illegal by the Taft-Hartley Labor Act of 1947.

Agency shop: Both union and nonunion members are hired. Nonunion members pay a fee to support the union's efforts to improve wages, hours, and working conditions.

- Wage rates and policies.
  a. Lists pay rates for various jobs, Fig. 22-19.
  b. Lists methods of paying workers during downtime and other periods when the plant is not running normally.
- Hours of work.
  a. Describes the workday and workweek (normally, an 8-hour workday and a 40-hour workweek).
  b. Describes overtime pay. This is pay for work beyond the normal workday or workweek.
- Vacations and holidays
  a. Lists who is eligible for vacations.
  b. Describes lengths of vacations and when they must be taken.
  c. Lists paid holidays.
- Employee dismissal policies.
  a. Describes methods of selecting, promoting, and dismissing workers.
  b. Describes the use of seniority (length of employment) in choosing who will be affected by the above actions.
- Working conditions.
  a. Describes sanitary facilities to be provided.
  b. Lists provisions for worker safety and health.
  c. Describes medical care to be furnished.
- Grievances.
  a. Defines what is considered a grievance.
  b. Outlines the procedure to be used to adjust grievances.
  c. Sets time limits for filing and processing grievances.
- General provisions.
  a. Gives general rules for using the time clock,

XYZ CORPORATION
Wage Rate Schedule

LABOR GRADE	PAY RATE	STARTING STEP			FIRST STEP			SECOND STEP		
		ONE	TWO	THREE	ONE	TWO	THREE	ONE	TWO	THREE
10		7.11	7.17	7.24	7.15	7.21	7.28	7.21	7.27	7.34
9		7.15	7.21	7.28	7.21	7.27	7.31	7.31	7.37	7.44
8		7.21	7.27	7.31	7.31	7.37	7.44	7.37	7.43	7.50
7		7.31	7.37	7.44	7.37	7.43	7.50	7.55	7.61	7.68
6		7.37	7.43	7.50	7.55	7.61	7.68	7.64	7.70	7.77
5		7.55	7.61	7.68	7.64	7.70	7.77	7.76	7.82	7.89
4		7.64	7.70	7.77	7.76	7.82	7.89	7.90	7.96	8.03
3		7.76	7.82	7.89	7.90	7.96	8.03	8.04	8.10	8.17
2		7.90	7.96	8.03	8.04	8.10	8.17	8.26	8.32	8.39
1		8.04	8.10	8.17	8.26	8.32	8.39	8.48	8.54	8.61

Fig. 22-19. A typical wage schedule from a union contract.

leaving a work station, and setting up a union bulletin board.
   b. Lists and describes company pension and insurance plans.
- No-strike clause.
   a. Provides for strike-free operation during the life of the contract.
   b. Outlines penalties for illegal strikes. A strike during the contract period is called a **wildcat strike** and is illegal. The company can fire anyone who takes part in a wildcat strike. Action this drastic is seldom taken.
- Life of the contract. Sets the length of time the contract is in effect (usually one to three years).

The contract is the *rule book* by which managers and union members must operate. It provides for the basic interaction between these two forces in all unionized firms.

HANDLING GRIEVANCES

The contract is worked out through collective bargaining. It then must be put into practice, though. Managers and workers must read and interpret the written word. There is always a chance for misunderstanding.

From time to time, managers may fail, or *seem* to fail, to live up to the contract. The manager may not fully understand the contract or may forget a specific clause. For the same reasons, workers may not realize that the manager *is* applying the contract fairly.

In either case, a dispute exists. In the contract, there is a means to adjust such misunderstandings. It is called the *grievance procedure*. A grievance is an *official complaint* filed by the union or an employee over a contract issue. A typical form used to file a grievance is shown in Fig. 22-20. The complaint may relate to an action taken by management. It could also involve an interpretation of the contract.

Steps in handling a grievance

The grievance procedure is a series of steps or levels to which a complaint may be taken. Each step brings in a higher official of both the company and the union, Fig. 22-21.

As the first step, the steward and the worker discuss the complaint with their supervisor. The dispute may be cleared up at this point. The supervisor may correct the mistake, if one was made. The worker may find that the supervisor's action did not violate the contract.

If the grievance is not settled at this first step, further action is needed. Usually, a committee of stewards will review the grievance to decide if it has merit.

If the stewards decide to pursue the matter, their representatives will often meet with the plant manager or personnel director. Again, the grievance may or may not be settled at this point.

If a third step is needed, higher officials of the company and the union get involved. The local union will call in a representative from the national union. This representative presents the work grievance to management.

If agreement cannot be reached, the matter may go to arbitration. In that process, a *disinterested* person (someone with nothing to gain from the decision) hears from both parties involved. The arbitrator studies the facts and makes a ruling. The decision is binding on both the union and the company.

The grievance procedure provides an orderly way to settle disputes during the life of the contract. It keeps unresolved issues from piling up and creating ill will between the company and the workers.

SUMMARY

Unions are a direct or indirect force in almost all manufacturing plants. They place pressure on man-

GRIEVANCE FORM

Make original and three copies to be distributed to:
1) management 2) steward 3) chief steward
4) aggrieved worker

Employee _____ **Clock #** _____

Job Title: _____ **Dept:** _____ **Shift:** _____

Seniority: _____ **Supervisor:** _____

Nature of Grievance: _____

_____

_____

_____

(Use additional sheets of paper if necessary)

Adjustment Desired: _____

_____

_____

_____

Date: _____ _____ _____

Signatures: **Employee** **Steward**

Fig. 22-20. A typical form used to notify everyone involved that a grievance has been filed. (AFL-CIO)



Fig. 22-21. If a grievance is not settled with the worker's immediate supervisor, it can move through a series of steps until it is settled. (AFL-CIO)

agement for good wages, hours, and working conditions. Workers belong to local unions, which are usually part of a national or international union. These unions are directed by elected officers who respond to policies made at union meetings and conventions.

A union enters into collective bargaining with a company. The result is a labor agreement or contract. The contract outlines basic policies on wages, hours, and working conditions. It also includes a method for settling disputes between labor and the company. This system is called the grievance procedure.

KEY WORDS

All the following words have been used in this chapter. Do you know their meanings?

AFL-CIO
arbitrator
bargain
biennially
certificate of representation
collective bargaining
committeeman
conciliator
constitution
convention
delegates
expel
federations
grievance
international union
job security
local union
managers
mediator
National Labor Relations Act of 1935
national union
negotiators
organized labor
parliamentary procedures
political power
prevailing wages
strike
unfair labor practices
union contract
union organizer
union steward
wildcat strike

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Name several kinds of manufacturing businesses that could be affected by a steel strike.
2. True or False? One of the goals of organized labor is to encourage workers to register and vote in elections.
3. The AFL-CIO is a _____ of national labor unions. It has ____ affiliated unions with more than 60,000 locals.
4. Five of the nine steps involved in forming a local union are shown below. Fill in the four that are missing.
   1. Survey the company.
   2. Form the plant committee.
   3. _____.
   4. Obtain authorization cards.
   5. _____.
   6. _____.
   7. Set the election date.
   8. _____.
   9. Award certificate of representation.
5. Name the three major offices in a local union.
6. The operation of a local union is governed by its _____.
7. A major responsibility of a union is to
   a. Provide health insurance for members and their families.
   b. Negotiate a contract for its members.
   c. Sponsor social and recreational activities.
   d. Involve its members in political activities.
8. The process of working out a contract between labor and management is called "collective _____."
9. A strike that takes place during the period covered by a labor contract is illegal. It is called a _____ strike.
10. True or False? Union stewards seldom get involved with the grievance procedure.

APPLYING YOUR KNOWLEDGE

1. Develop a report roleplaying your school as a company and the student body as a labor union.
   a. Turn a sheet of paper sideways.
   b. Divide the sheet into four equal columns. Head the first column "Possible Areas of Disagreement;" the second column, "Student Position;" the third, "Administration Position," and the fourth, "Compromise."
   c. In the first column, list three areas of possible disagreement between students and the school administration.
   d. In the second column, list what you feel would be the student position on each of the issues.
   e. In the third column, develop the position you *think* the administrators would take on each of the issues.
   f. Now, take the role of an arbitrator. In the fourth column, work out a compromise position for each issue that you think would be acceptable to both sides.
2. Imagine that you are an organizer for a new "student's union." Create an organizing slogan for the group. Plan a promotional campaign using handbills, posters, and other means of communication. Make a list of the real issues you would address in persuading students to join your union.
3. Design a poster to promote membership in the "Technology Students' Union."

23

CHAPTER

MARKETING PRODUCTS

After studying this chapter, you will be able to:

- *Describe how trade names and trademarks are established for a company.*
- *List the steps involved in designing and producing advertising.*
- *Name the three major criteria involved in package design.*
- *Describe how marketing effort affects product sales.*
- *Demonstrate how best to sell a product to a customer.*
- *Identify ways products are distributed to customers.*



Fig. 23-1. The marketplace offers customers many products from which to choose. (UAW Solidarity)

Companies face a common challenge after products are designed and manufactured. They must sell their products to generate the desired profit. This is not as easy as it sounds. There are often a number of companies producing competing products. Each product vies for the attention and sales dollars of customers, Fig. 23-1.

Effective marketing of a product takes careful planning. Some essential tasks must be performed. These, as shown in Fig. 23-2, include:

1. Selecting a name and trademark to identify the company and the product.
2. Designing and producing advertising to persuade customers to seek out and buy the product.
3. Designing a package to protect and promote the product.
4. Planning for selling the product to insure that the right product reaches the right market at the right time and price.



Fig. 23-2. These are the steps in marketing a product.

5. Recruiting, selecting, training, and compensating a sales force to sell the product.
6. Distributing products to customers.

SELECTING A NAME AND A TRADEMARK

Store shelves and catalog pages are full of products fighting for attention. Many of these products compete with one another for the loyalty and money of customers. Companies want their products to be recognized and purchased. They want each customer to accept the product and the company as "old and trusted friends." A common way to establish this bond between customers and the product is through trade names and trademarks.

A **trade name** is the legal name of a company and identifies it to customers. General Motors Corporation, Sears, Roebuck and Co., and Black and Decker Manufacturing Company are examples of trade names.

Specific products manufactured or sold by a company must also be identified. A **brand name** is used to identify and differentiate (separate) a product from its competition. DieHard–batteries, Planters–peanuts, Buick– automobiles, and Bayer–aspirin are examples of brand names.

A brand name must be carefully selected. The name may dictate the direction for a number of marketing decisions. It must fit advertising and packaging plans, sales approaches, and customer attitudes. There are 12 simple rules for developing a brand name. The name should be:

- Simple.
- Short.
- Easy to read.
- Easy to spell.
- Easy to recognize.
- Easy to pronounce.
- Timely (in keeping with the times, fashions, etc.).
- Adaptable for advertising (print and electronic, black & white and color).
- Adaptable to packaging.
- In good taste (not offensive, obscene, or negative).
- Pleasing to hear.
- Suggestive of the product function or of the business of the company.

Think of several brand and trade names. Do they fit these rules? How about products called Kleenex, Wheaties, Pepsi, and Newsweek? Do you think General Motors Corporation, AMOCO, and K-Mart are good company names?

Developing a trademark is the second most important image decision. Often, the trademark and the brand name are used together. They must support each other by projecting a positive image for the company and its products.

A **trademark** is defined as a name, a graphic symbol, or a combination of a name and a symbol adopted and used by a company to identify a product. It is also used to distinguish a product from the goods made or sold by others. A trademark is a company's "fingerprint." No other company can have one like it. It is unique. See Fig. 23-3.

A good trademark, like a brand name, should be:

- Easy to see and recognize.
- Adaptable for advertising and packaging.
- Timely and in good taste.

Look at the trademarks in Fig. 23-3. Do they pass this test?

ADVERTISING THE PRODUCT

A company must inform its potential customers about the company and its new or improved products. In early times, word-of-mouth promotion was

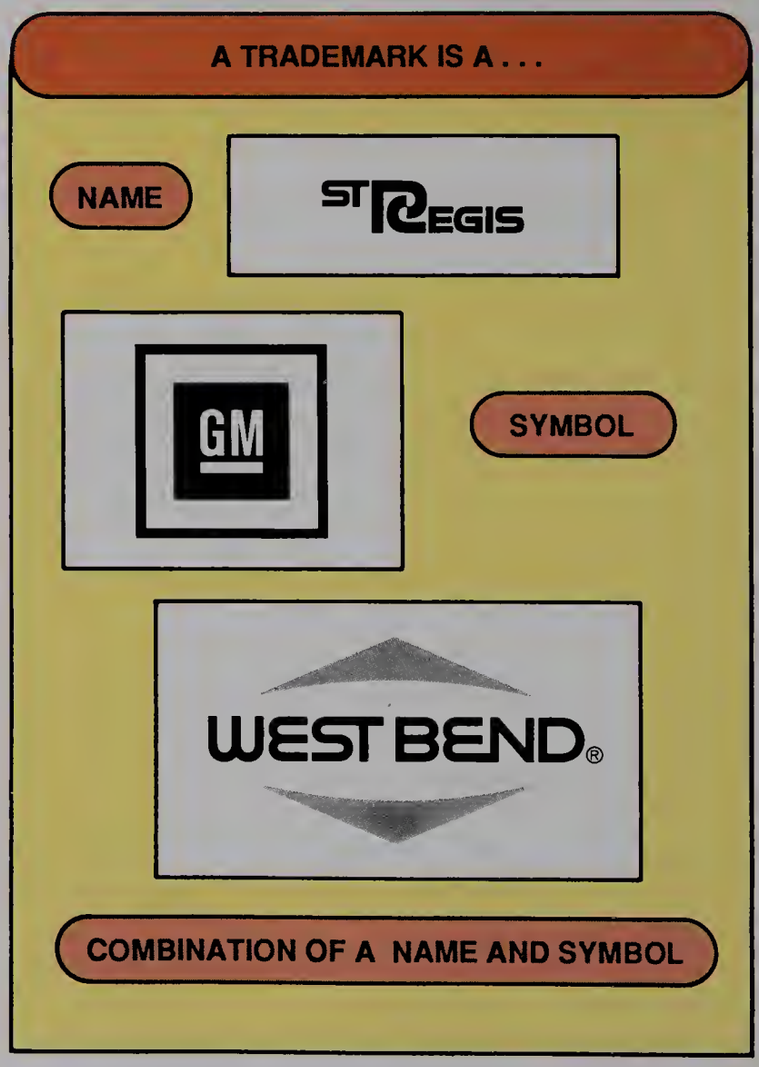


Fig. 23-3. Trademarks are used to identify a company and its products.



Fig. 23-4. This advertisement promotes a specific product of one company. (Goodyear Tire and Rubber Co.)

used. People simply told their friends about various merchants and their products. However, this system is ineffective in our complex world. Most companies use advertising to gain and hold customers.

Companies can use two basic types of advertising: product advertising and company or idea advertising. **Product advertising** promotes a specific product, Fig. 23-4. This type of advertising tries to convince the customer that brand "X" is better than brand "Y." In most cases, the features of brand X are presented, and brand Y is not mentioned. However, sometimes the products of competitors are directly mentioned and criticized. This type of advertising has been used at different times in the "hamburger wars" between McDonalds, Burger King, and Wendy's and in the "cola war" between Coca-Cola and Pepsi.

Company or idea advertising promotes a company in general or a specific idea. If you know the slogan "You're in good hands with Allstate," you have been impacted by company advertising. Your attitude toward the company is partly molded by this advertising slogan. By using various advertisements and slogans, companies want customers to feel safe in buying and using their products and services. The same type of advertising is used to develop social attitudes such as "Just say NO!" to drugs, and "Pitch In!" and dispose of litter properly, Fig. 23-5.



Fig. 23-5. This advertisement encourages a positive attitude toward disposing of litter properly.

Product advertisements are designed to perform three basic functions, as shown in Fig. 23-6. They inform people about the product and its features. Then they persuade people to find the product in a store or catalog and to buy it. Finally, advertisements remind people to buy the product again when the need arises.

However, advertising is not the only factor that affects sales, Fig. 23-7. Other important marketing factors include:

- The price of the product in relationship to competitor's products.
- The package that holds and displays the product.
- The point of purchase displays used to present the product in stores.
- The selling approach used by sales personnel.
- The product design, attractiveness, function, etc.

Advertising, then, is part of an overall marketing plan or "marketing mix." The goal of the **marketing mix** is to sell products to new customers and encourage repeat sales from previous customers.

A good advertisement takes a potential customer through four basic steps, Fig. 23-8:

1. Attract the attention of customers through physical means.
   a. Size of the print advertisement or the length of a radio or television commercial.
   b. Big, bold headlines or dramatic voices.
   c. Effective use of color.
   d. Startling or interesting pictures and graphics (line art).
2. Inform and build interest in the product.
   a. Convert attention to interest.
   b. Inform through copy (print) or the dialogue (actor's script). What is available? What are the properties of the product? Where can the product be purchased? What price advantages does the product have?
3. Persuade or create a desire to own the product.
   a. May be done in the first two steps, but should be considered as a separate element.
   b. Create brand or product acceptance.
   c. Reinforce previous purchases of the product.
   d. Establish a trademark or brand name.

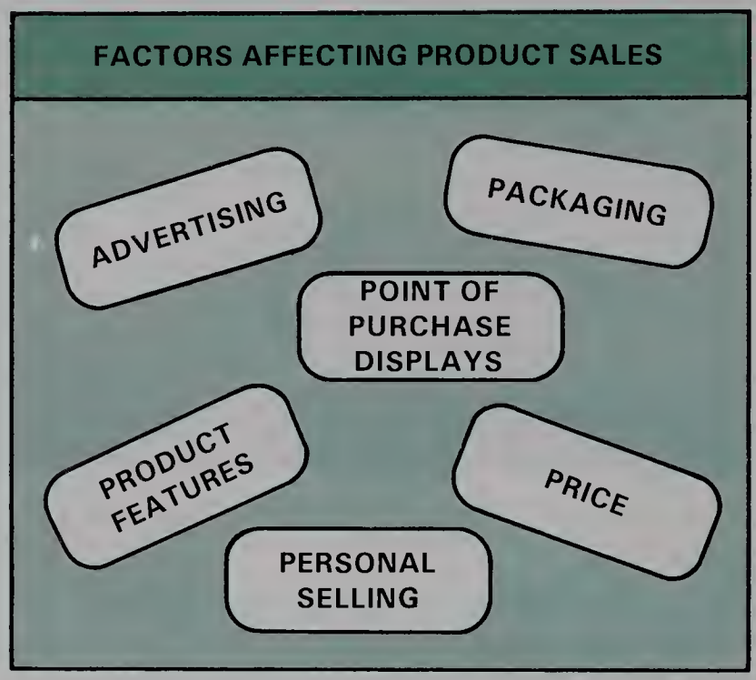


Fig. 23-7. These are the six factors considered in a marketing plan.

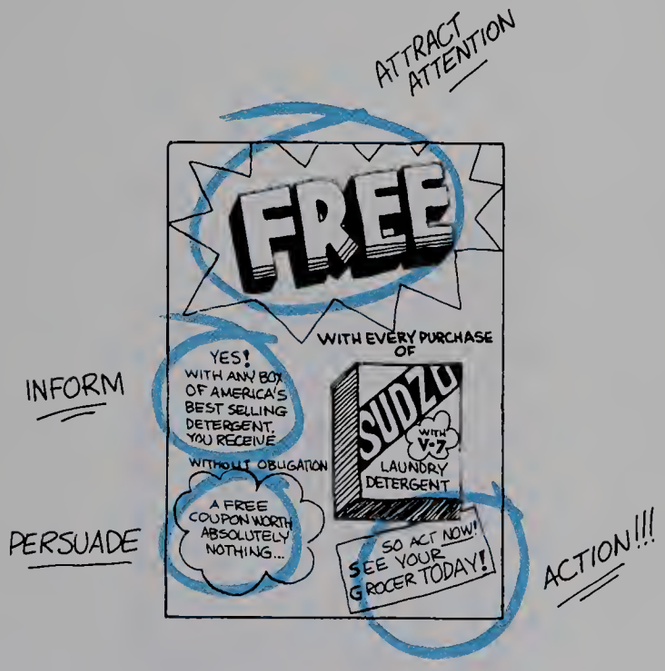


Fig. 23-6. A good advertisement will attract attention, inform, and persuade. Finally, it will cause the reader to act.

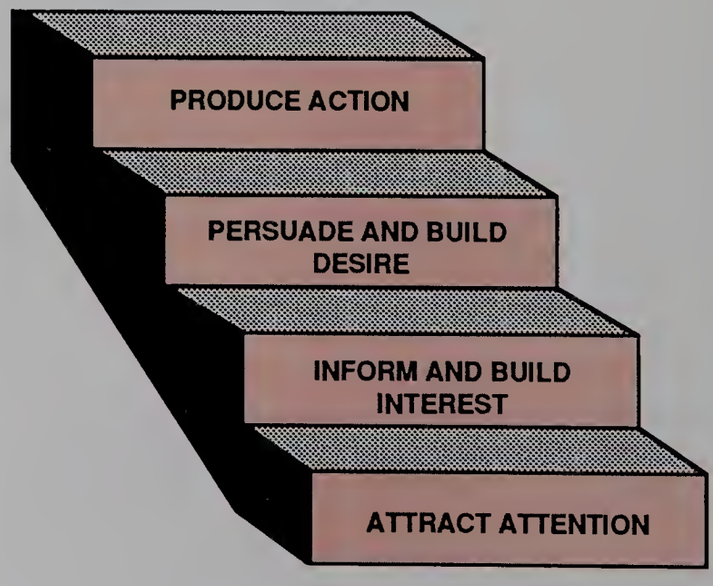


Fig. 23-8. A good advertisement leads the customer through these steps.

4. Produce action.
   a. Cause people to buy the product.
   b. Includes common marketing tools such a coupons, manufacturer's rebates, free gifts, recipes on the package, etc.

It's easy to list the four steps, but it's much more difficult to design an advertisement that meets all of them. Study the advertisement shown in Fig. 23-4. Evaluate its ability to attract attention, inform, and persuade. Do you think it would cause potential tire buyers to seek out the product? When you are home, watch a television commercial and analyze it using the same factors.

The advertisement you analyzed in Fig. 23-4 was developed according to a basic pattern. It was the result of the work of marketing personnel from the company and an advertising agency. The **advertising agency** is a specialized company that has experience and talent in developing effective advertising media.

The advertising development pattern involves two main stages. These are developing a theme and designing and producing the advertisement.

DEVELOPING AN ADVERTISING THEME

Advertisements need a focus and a thread of continuity. These features are provided by the theme, which is often called the **copy platform**. This copy platform is much like the platform of a political party. It lists the main objectives of the advertising campaign. It outlines the strategy for meeting the advertising goal: to gain and hold customers for the product.

The copy platform does not present a specific advertisement. It gives the necessary direction or outline for developing the actual advertisement.

DESIGNING AND PRODUCING AN ADVERTISEMENT

An advertising campaign often uses both print and electronic (television and radio) media. These advertisements are carefully designed to fit within the approved theme. They are developed with the audience in mind: who they are; where they buy products; what they buy; how much they have to spend. Also, a complete knowledge of the product to be advertised and the competing products is needed.

The procedure for developing print advertisements is different from that used for electronically communicated commercials. The print media will be discussed specifically, and radio and television commercials will be highlighted.

Print advertisements

Advertising specialists prepare print advertisements using information gathered about the audience, the product, and competing products. The specific advertisements are developed through three stages, as shown in Fig. 23-9:

1. Copy preparation.
2. Layout.
3. Production.

Copy preparation determines what will be said to the customer. It involves preparing an effective message about the product and its features. The copywriters may use one of several approaches. They may

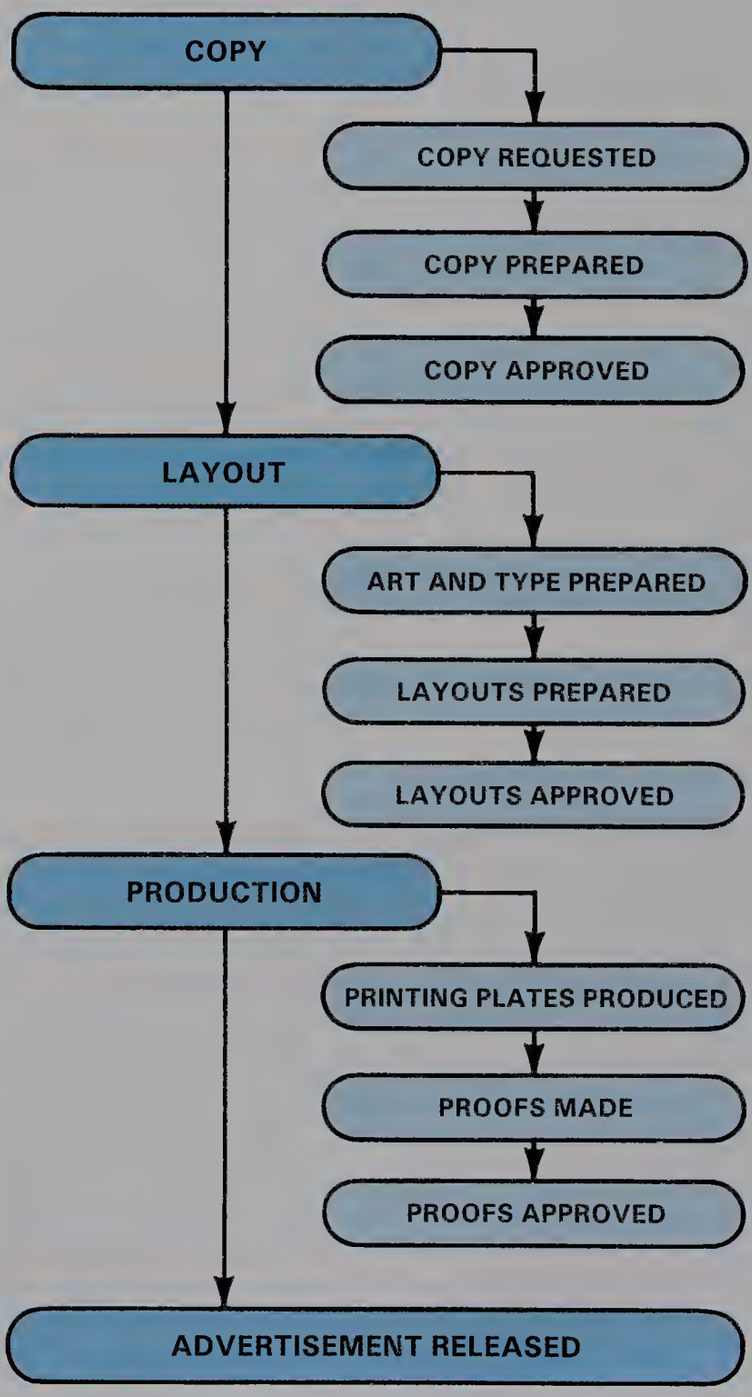


Fig. 23-9. These are the steps involved in producing an advertisement.

appeal to the logic of the customer. The advertisement may present facts and specific advantages of using the product. That is, the advertisement may appeal to common sense. Typical *logical appeals* stress low price, life of the product, dependability, ease of use, or efficiency. This approach is often used for industrial products and more expensive consumer goods.

Another type of advertisement has an *emotional appeal*. The approach may play on people's desire to be accepted. It may stress being more attractive, popular, successful, or intelligent. The emotional approach is used for products that are very similar to those of the competition. It develops a perceived (or mental) difference between one product and others on the market. Emotional appeal is used for low-cost consumer goods such a cosmetics, beverages, soaps, and designer clothing.

Once the approach is determined, **copy** must be written, Fig. 23-10. This is the message that will be conveyed to the reader. This material is then reviewed by various marketing personnel.

Meanwhile, a **layout** is prepared. The layout arranges the various parts of the advertisement into a pleasing format. It considers the location and size of various elements including:

- Headlines and captions.
- Pictures and/or art.
- Company trademark, product brand name and/or slogans.
- Copy (printed message).

The layout, Fig. 23-11, will have a direct effect on the attractiveness and effectiveness of the advertisement. Like the copy, the layout is submitted to marketing managers for approval.

The approved copy and layout must be integrated into a complete advertisement, Fig. 23-12. Artists and layout personnel, like the person shown in Fig. 23-13, prepare **comprehensives** or mechanicals. These are exact copies of the advertisement as it is to appear in the publication.

The comprehensives are then submitted to the publication or printer for reproduction. They may become pages in magazines or newspapers, billboards, or flyers distributed at a store.

Radio and television

Similar steps are used to produce radio and television commercials. However, their actual production acts are much different. Scripts are written instead of

or

Complexity is no longer objectionable

It began to happen quite recently. Engineers, realizing that the mythical mind of the well-programmed and capacious digital computer does not boggle, put it to work translating mind-boggling complexities of logic into physical form. The ancient philosophers who invented logic as a game that is all in the mind had perhaps never actually encountered minds that do not boggle. To put logical constructs into a physical form that is readily multiplied, one turns to a craft generally credited to Gutenberg. The particular physical form, whether a metal-oxide-semiconductor (MOS) chip, a bipolar integrated circuit, or a charge-coupled device (CCD), rests also on subsequent contributions by the artists who invented photography, by the inorganic chemists who vied to discover new elements in rocks, by the physicists who invented quanta and electrons to explain their experiments, by the organic polymer chemists, even by us in one small way or another.

The physical form comes down to a bit of jewel patterned in lines and dots much finer than those by which a printing press prints pictures. The scanning electron microscope discloses thousands of electronically active and passive components tied together by logic. Economies of duplication and size for costly materials of the rarest purity open mass markets for all manner of artifacts that interact with the customer's central nervous system, homunculi who live in tiny boxes and are looking for new work beyond telling time and performing difficult calculations. When complexity is affordable, one can do almost anything.

The technology that generates the dots for the printing press turned out to be the way to carve and deposit the patterns the computers generate. From serving the printing and graphic arts industry for a long time, we know that technology well and currently serve the photolithographic departments of today's electronics industry not only with high-resolution plates and light-sensitive resists but by encouraging communication within their craft.

Here, for example, are the titles of papers presented at the most recent of the Kodak Microelectronics Seminars:

The "Oxygen Effect" in Photoresists and Its Manifestation in Processing Parameters
A Laser Reticle Generator
Performance of an EBPG (Electron Beam Pattern Generator) as a Link in a Semiconductor Chip Manufacturing Chain
Mechanistic Aspects of Photocrosslinking in Negative Photoresists
Modelling Positive Photoresist
An Electrical Method for Detecting Pinholes
Effective Water Removal from High-Resolution Plates
Advances in Contact and Proximity Printing
Holographically Prepared Gratings for Integrated Optics
Chrome Is for Car Bumpers and LSI Mask Technology
The Characterization of Positive Photoresists
Processing Techniques
The Chemistry and Control of Processing High-Resolution Plates
Lenses and Optical System Used in Microelectronics
Monosubstituted Vinyl Polymers as Highly Sensitive Negative Electron Beam Resists

If any of them specifically interest you drop us a note at Dept. 55W, Kodak, Rochester, N.Y. requesting a copy.

Message to a few very special people who all too well know the reality of it all

There is more to the art than photolithography, of course. Now is the time we start building reliability into clever Kodak apparatus as much as a decade away from the marketplace. S. C. Wright, Business and Technical Personnel, Kodak, Rochester, N.Y. 14650 seeks the acquaintance of a few individuals highly qualified by direct practical experience to begin a new career in a research laboratory environment where the scientific underpinnings of MOS technology are to be extended. Wright also would like to know of others who are very good at designing IC's, or at directing fabrication of prototypes of new designs to prove out in working products. This must long precede production orders placed with suppliers of IC's. We are an equal-opportunity employer f/m.

Fig. 23-10. This is sample copy prepared for an advertisement. (Eastman Kodak Co.)

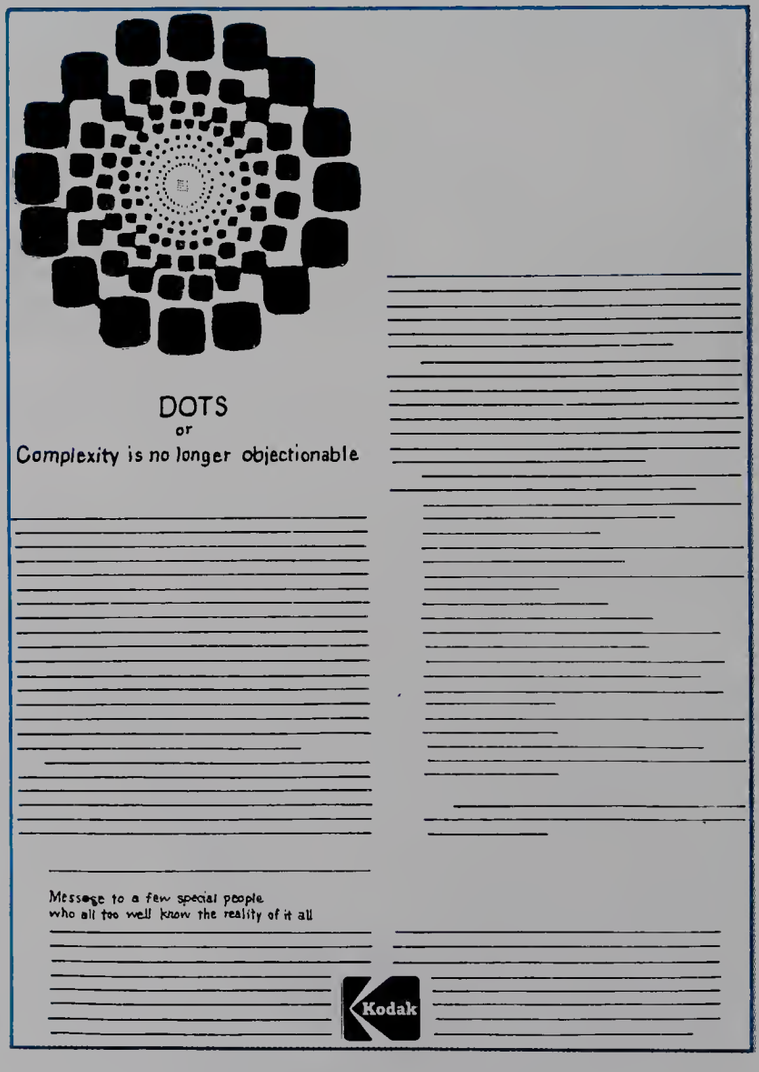
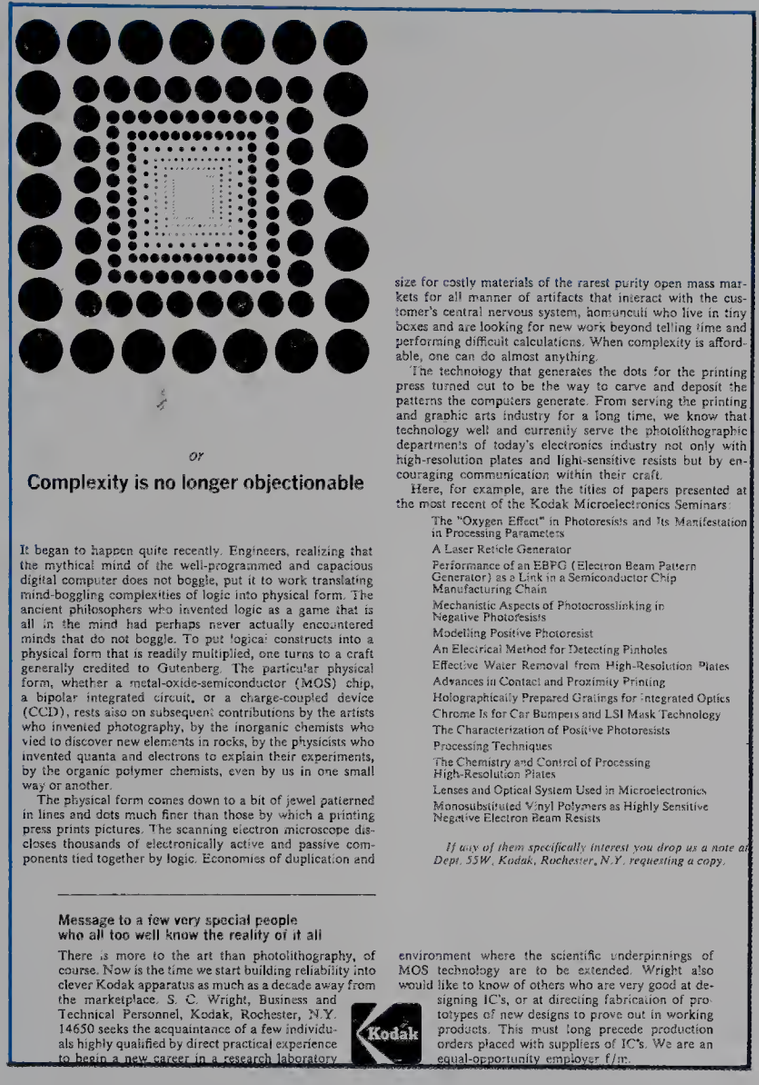


Fig. 23-11. A sample layout for a print advertisement is shown here. (Eastman Kodak Co.)



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Kodak

Fig. 23-12. This is a comprehensive (final proof) for a print advertisement. (Eastman Kodak Co.)

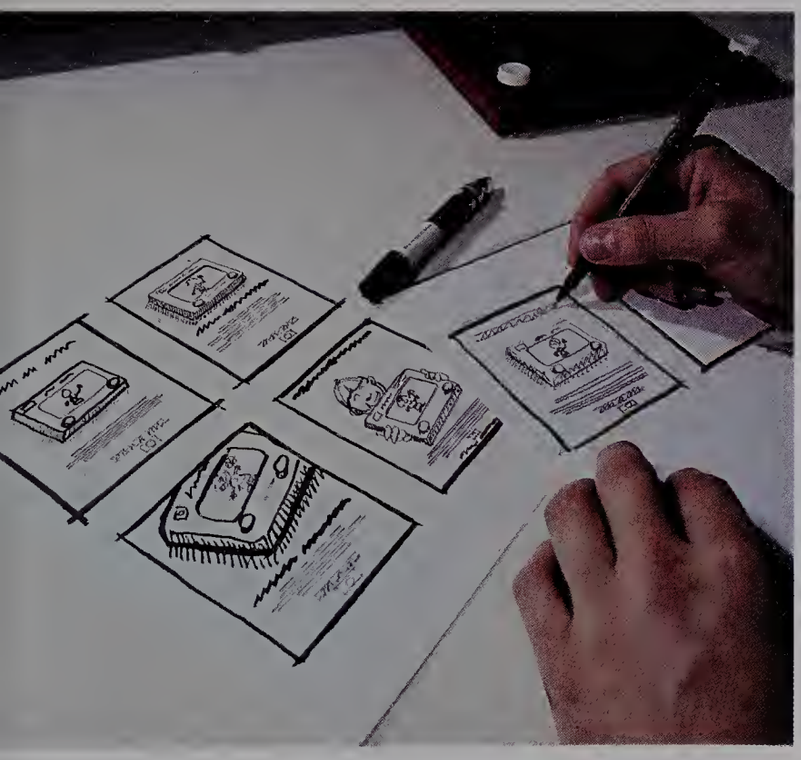


Fig. 23-13. This artist is preparing an advertisement for the toy on the drawing table. (Ohio Art Co.)

copy. **Storyboards** (a series of sketches showing the sequence of camera shots) and staging are used instead of layouts. Cameras, microphones, and recording equipment replace the printing press. The result is still the same: a media message that is designed to encourage people to act. The goal of this type of advertising is that after hearing and/or viewing the commercial, customers will buy a product, think well of a company, or become more socially responsible.

DESIGNING AND PRODUCING A PACKAGE

An important marketing tool that is closely related to the goals of advertising is **packaging** (the way in which a product is presented to a customer), Fig. 23-14. This is particularly true of low-cost, consumer goods. The package is another way to attract attention, inform, and persuade customers. A bright, attractive package will help sell the product. To appreciate this fact, simply look at any shelf in a supermarket or toy store.

A good package must be carefully designed to meet the three major criteria shown in Fig. 23-15:

- It must contain and protect the product during shipment and display in stores. The product must be protected from rough handling, odors, moisture, sunlight, and other conditions that can reduce its value.
- It must persuade the customer to purchase the product. The package must attract the attention of customers. Then the product must be displayed in a way to persuade customers to consider buying the product.
- It must provide product use directions and related information. The package is a vehicle used to



Fig. 23-14. Packaging is an important part of a marketing plan. (Graphic Arts Technical Foundation)

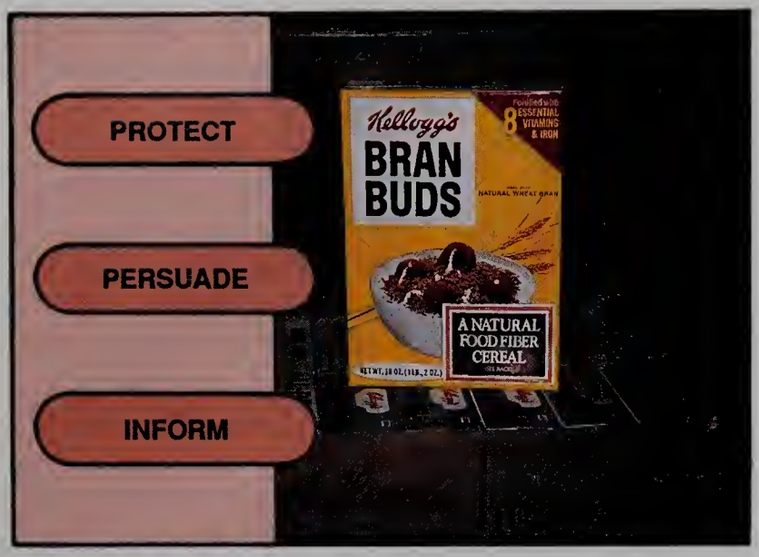


Fig. 23-15. A package should contain and protect the product, persuade customers to buy it, and provide information.

convey information about the manufacturer of the product; important features; nutritional value; and operation, care, and maintenance.

Designing a package involves three major steps. These include:

1. Analyzing the packaging need.
2. Selecting a proper container.
3. Preparing graphics (printing) for the package.

ANALYZING PACKAGING NEEDS

Each product has its own packaging needs. Many ceramic products can be damaged in shipment. Some food products can pick up odors in warehouses and trucks. Sunlight can fade delicate fabrics. Heat will melt chocolate or wax. Moisture will cause soap powders to dissolve and cake. These are just a few examples of the concerns facing each package designer. The designer must consider several factors when starting to design a package. These include:

- Type of product.
- Need for protecting and transporting the product.
- Customer desires and attitudes about the package.

Each of these factors must be analyzed and described. Often, a written description of the packaging needed is prepared. Included in this description is the following information:

1. Product description:
   a. Product name.
   b. Physical form: solid, liquid, paste, gel, gas, etc.
   c. Product characteristics: fragile, corrosive, abrasive, etc.
   d. Typical quantity sold: each, pair, dozen, gallon, pound, etc.
2. Protection requirements; need to protect product from:
   a. Moisture.
   b. Breakage.
   c. Theft.
   d. Dirt, grease, other outside elements.
   e. Evaporation.
   f. Bright light.
3. Informational requirements:
   a. Information required by law.
   b. Safety considerations.
   c. Care and use.
   d. Manufacturer's name and address.
4. Market considerations:
   a. Size and shape preferred by customers and retailers.
   b. Quantity of products bought at one time by the retailer and the customer.
   c. Ease in handling, opening, and resealing.
   d. Type of display (shelf, rack, etc.) used to hold the product in the store.

SELECTING A CONTAINER

The description of the packaging needs helps designers approach the second decision: selecting a container. Common product containers include bottles and jars, boxes, cans, trays, bags, and tubes. These containers may be made from paperboard, corrugated cardboard, plastic sheets and films, metal sheets and foils, glass, or wood.

The material and container shape must be carefully chosen to address:

- Cost.
- Availability.
- Ability to meet the package requirement.
- Ease of manufacture.
- Ease of placing the product into the package.

Once the package type and shape are selected, the designer must design the basic form. Plastic, glass, and metal bottles, jars, and cans are available in a wide range of sizes and shapes. They are produced using material forming processes discussed in Chapter 8. The empty containers are shipped to the manufacturing plant to be filled with product, Fig. 23-16. They are generally placed in a shipping carton for transportation and storage.

Many consumer products are packaged using plastic sheets and films. Five typical packages using these materials are shown in Fig. 23-17. These are:

- *Formed tray:* The product is placed in a preformed tray that was produced using the thermoforming process. The tray is then placed in a paperboard

box or sleeve that contains the package graphics. This package provides good protection for fragile or otherwise easily damaged products.

- *Blister package:* The product is placed in a thermoformed plastic blister. The blister is then adhered to a card containing the package graphics. Blister packs are widely used as a visible display for hardware, tools, and small parts. They eliminate the need to count out products and help to reduce theft.
- *Shrink package:* The product is placed on a card that contains the package graphics. The plastic sheet is thermoformed around the product and adheres to the card. Shrink packs fulfill the same function as blister packs.
- *Clam-shell package:* The clam-shell package is actually a double blister package. It is used for symmetrical products such as light bulbs.
- *Bags:* Plastic bags are generally produced from continuous tubing. A proper length piece of tubing is cut from a roll and one end is sealed. The product is placed in the formed bag, then the second end is sealed.

Other important types of packaging for consumer goods are made from paperboard. They include a wide variety of boxes found in supermarkets, hardware stores, and discount stores. Paperboard packages come in an almost unlimited variety of sizes and shapes. Four common boxes and their layouts are shown in Fig. 23-18.

Generally, paperboard boxes are cut from sheets of stock that already have the graphics printed on them. They are then scored (creased) so that the material can be folded into the proper shape. The box generally remains flat until it is to be used. The material is then folded and glued, creating the final box.

PREPARING PACKAGE GRAPHICS

Preparing package graphics is the final package design task, Fig. 23-19. Many of the advertising design principles discussed earlier apply to package design. A package must be well designed to attract and



Fig. 23-16. These cans are being inspected before they are shipped to a paint manufacturer. (ARO Corp.)

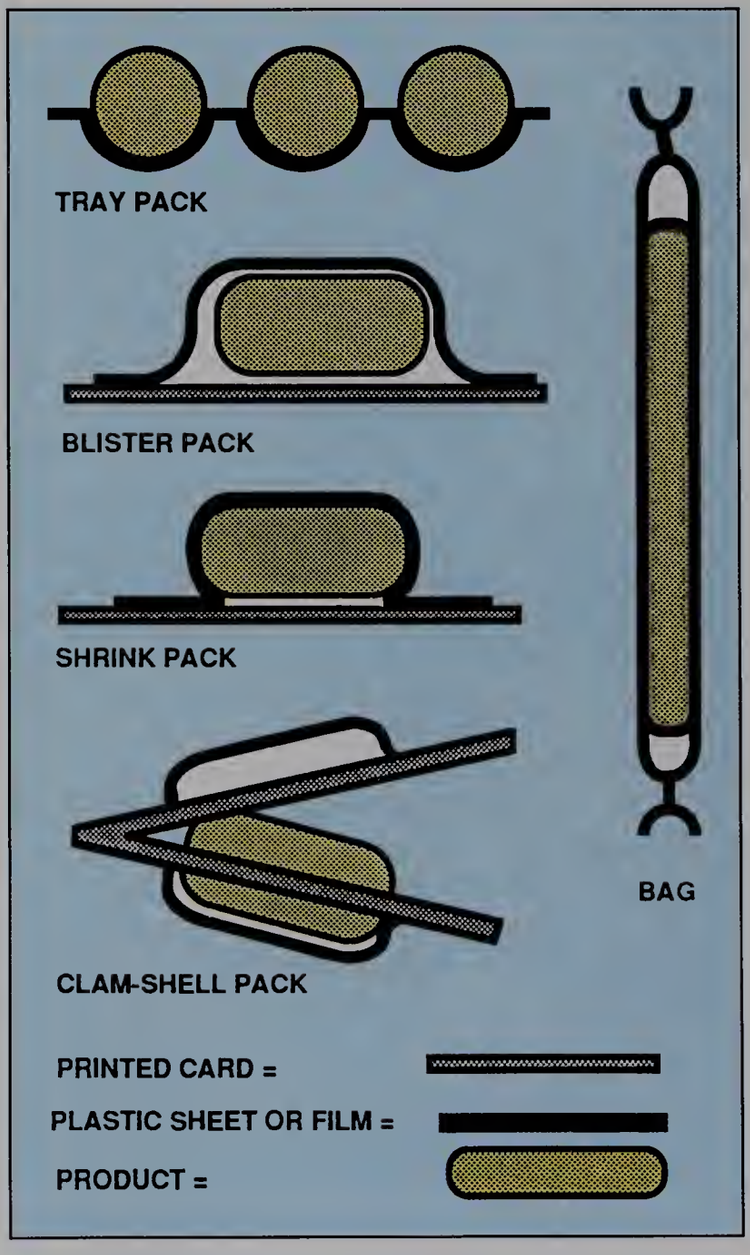


Fig. 23-17. These are typical plastic film and sheet packages.

keep the attention of customers. Included in the package design considerations are:

- Product identity.
  a. Are the trademarks and brand names clearly visible?
  b. Will the package shape help display and sell the product?
  c. Is the description of the product clearly presented?
- Package decoration.
  a. Are the colors pleasing?
  b. Do the colors go with the product and its use, Fig. 23-20?
  c. Is the layout uncluttered and attractive?
  d. Is the printing clear and legible?
- Customer acceptance.
  a. Is the package pleasing close-up and at a distance?
  b. Does the package meet the expectations of customers for rigidity, opening ease, and resealing?

In addition to a pleasing appearance, the package must contain vital information. A typical package

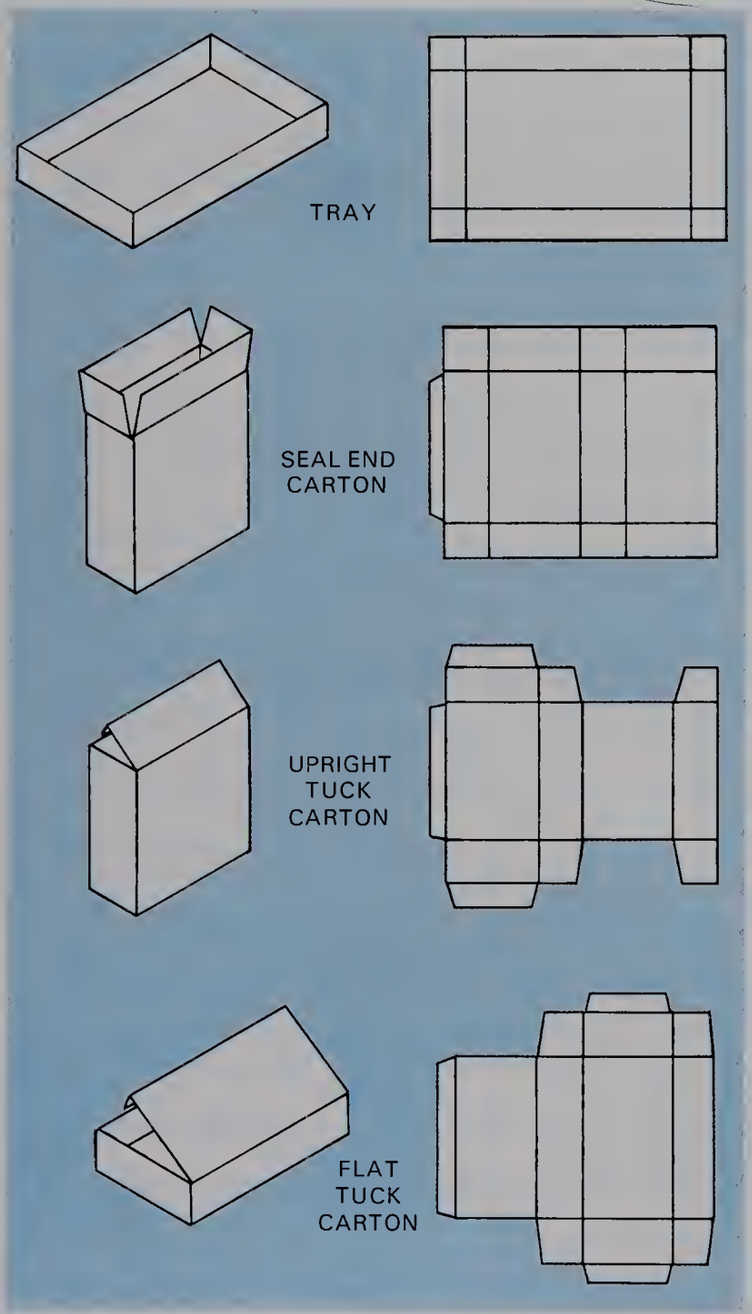


Fig. 23-18. Four common paperboard packages and their flat layouts are shown here.



Fig. 23-19. This designer is developing a package for a popular toy. (Ohio Art Co.)

COLOR	IMPRESSION	ASSOCIATED WITH:
BLACK	SOLEMN	DEATH, MOURNING, DARKNESS, EMPTINESS
WHITE	PURITY	CLEANLINESS, WINTER, MOTHER'S DAY
RED	OFFICIAL, CLOSE TO THE HEART	CHRISTMAS, VALENTINE'S DAY, FOURTH OF JULY, DANGER, FIRE, WARMTH
BLUE	PRIZE WINNING, COOL AND REFRESHING	WATER, SKY, CLEANLINESS, CLEARNESS
YELLOW	CHEERFULNESS BRIGHTNESS	SUNLIGHT, CAUTION, DAYTIME
GREEN	COMFORT, NATURAL	ST. PATRICK'S DAY, NATURE, GROWING THINGS
PURPLE	DIGNIFIED, EXCLUSIVE	EASTER, REALITY, EVENING
ORANGE	HAPPY, GLOWING, FRIENDLY	HALLOWEEN, THANKSGIVING, FALL

Fig. 23-20. Selecting the right color to convey the right message is important in advertising and package design.

will contain the following information according the rules listed below:

- Product name:
  a. Is legible.
  b. Gives an accurate description of the product.
  c. Coined names (made up words) accurately describe the product.
- Descriptive information:
  a. Gives the name and address of the manufacturer or distributor.
  b. Provides adequate directions for use.
  c. Lists necessary safety warnings.
- Listing of the quantity of product in the package:
  a. Appears in a clearly visible location.
  b. Conforms to standard industry practice.
  c. Gives accurate volume or weight measures when appropriate for the product.

PLANNING FOR SELLING

Sales planning involves getting the right quantity of the right product to the right place at the right time to sell at the right price. Basic information about who the market is, how much it will pay, and what products it wants was gathered through market research. The task now involves interpreting the data to insure that the customers have the products they want at a price they are willing to pay.

Setting the selling price is a critical decision. Too high a price will reduce sales below a profitable level. Too low a price will not allow the product to be profitable. The Small Business Administration (a U. S. Government agency) suggests that companies should consider a four-layer cake when setting product prices, Fig. 23-21. Each layer represents a major element in the price. These elements are:

- *Direct costs:* This is the cost of actual material and labor involved in producing the product.

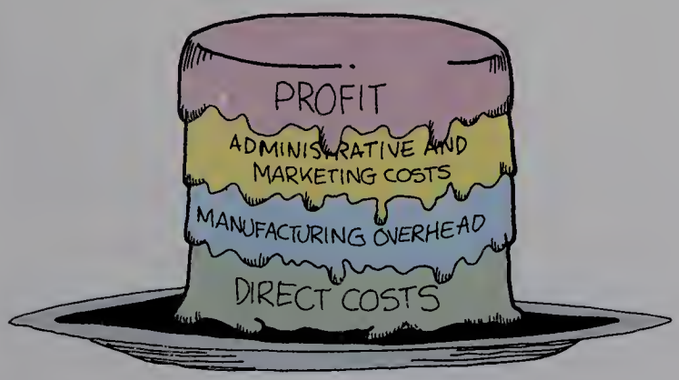


Fig. 23-21. Four main cost elements must be considered in determining the selling price of a product. Each layer represents an element to be considered when setting the price of a product.

- *Manufacturing overhead:* These are manufacturing costs above direct materials and labor including utilities, indirect materials, labor, etc.
- *General overhead:* These are the administrative and marketing costs involved in operating the company.
- *Profit:* This is the portion of the sales dollar left after all expenses are paid.

The best selling price is not necessarily the one that will move the most products. If you give a product away, your market is almost infinite. The "best" price is the one that generates the maximum profit for the company. At this point, profit is maximized.

The **maximum profitability point** (the point at which a company makes the most profit it possibly can from a product) is difficult to determine because many factors affect sales volume. These include:

- Selling price of competing products.
- Availability of substitute products and their price.
- Government regulations.
- Previous pricing patterns (such as the old nickel candy bar).
- Attitude of customers toward prices.

These facts plus good judgments about "what the market will bear" and "what is a reasonable profit" provide the basis for pricing a product. Remember, the primary factor in determining the profitability of a company is a sound product pricing policy.

SELLING THE PRODUCT

The final test for all product design and production activities is in the selling effort. Unless the product is sold, nothing else matters. The most efficient manufacturing system will not save the company. Money from sales is needed to meet all the expenses incurred by the enterprise. Therefore, the sales effort is critical.

Potential customers must be approached. Important factors about the product must be presented. Then the product must be exchanged for money.

There are two basic levels of sales. The first is the sales that occur between the manufacturer and its distributors (wholesalers and retailers). The distributors are interested in a unique set of product factors. They want to know how well the manufacturer will support their advertising and sales efforts; the intended profit margin for the product; and how often the inventory will turn. One **inventory turn** is the time it takes an initial order to sell. The higher the turns the better it is for the retailer.

The second level involves the final customer purchase of the product. The customer is interested in

product features: selling price, appearance, functionality, safety, maintenance, and durability.

The manufacturer must develop a channel for the product to move from the factory to the final customer. Chapter 15 introduced the three basic ways this happens. In the first, the manufacturer sells products directly to the customer through catalogs or a sales force. Some cosmetics, many encyclopedias, and some vacuum cleaners are sold this way. The salesperson who calls on the customer represents the manufacturer.

In the second method, the manufacturer sells products to the retailer. The retailer, in turn, sells the product to the final customer. Most new automobiles and many appliances are sold this way. When you see the terms "franchised dealer" or "authorized dealer" you are dealing with this method of sales.

The third method is the most common method of selling products. The manufacturer sells the product to regional wholesalers, Fig. 23-22. These companies operate warehouses and have sales personnel who service retailers in a geographic area. The wholesaler generally sells the products from a number of different manufacturers to selected retailers. These businesses sell them to the final customer. A typical example of these types of sales is the large hardware wholesaler who can supply a store with a complete assortment of hardware, tool, and housewares items. Local hardware store managers have little or no contact with the manufactures of the products in their stores. Their loyalty and commitment are with the wholesaler because he or she is a single source for most of the store's needs. This system makes buying inventory for the store relatively simple and routine.

All three of these methods require two major selling support systems. These are:

- A sales force development system.
- Sales record system.

SALES TRAINING

Sales personnel must understand their products and the market. They must know the features of their products, their competition, the potential customers, and the art of selling. Their job is to properly present the product to customers and to close sales. This involves training and study, Fig. 23-23.

The salesperson is trained to move the potential customer through six sales steps:

1. Introduction of the salesperson as a representative of the company.
2. Attract the attention of the customers:
   a. Present the exclusive or interesting features of the product.
   b. Promote the product without attacking the competition.
3. Sell the product:
   a. Develop customer confidence in the product and salesperson.

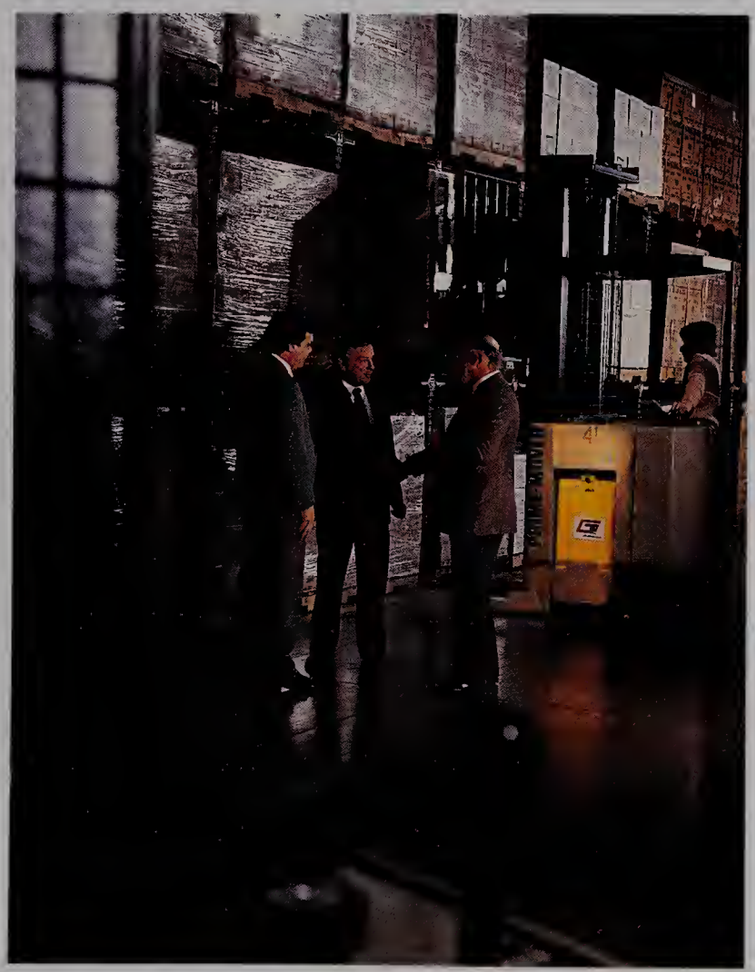


Fig. 23-22. Regional wholesalers are making a purchase from a furniture manufacturer. (Hon Industries)



Fig. 23-23. These salespersons are receiving training about a company's products. (AMP Inc.)

b. Develop a desire to own the product by pointing out: ease of operation and maintenance, value, quality, and performance.
c. Suggest possible uses for the product–self, gift, etc.
d. Convince the customer that the product will fit this use.

4. Answer possible objections:
   a. Too busy.
   b. Price too high.
   c. Similar products are already on the market at a lower price.
   d. Will think it over.
5. Make the sale:
   a. Reconfirm price and quantity ordered.
   b. Complete paper work.
6. Close the dealings with the customer:
   a. Reassure customer about the wisdom of the purchase.
   b. Thank customer for the order.

The above outline is for a retail sale. The same steps are used for sales to wholesalers and retailers. However, the information in the sales phases is different. Here, the salesperson has to convince the buyer that the product will serve his or her customers' needs, earn a good profit, generate repeat sales, and be supported by the manufacturer.

SALES RECORDS

At the end of the sales call, the salesperson will, hopefully, complete two forms. The first is a **sales call record**. This form details each contact with a customer by listing the customer's name, address, and buying decision.

The second form is a **sales order** that records each product sale. This form will list the name and address of the customer, the type and number of products purchased, the unit and total price of the items sold, and other information such as terms of the sale, delivery date, and shipping information.

DISTRIBUTING THE PRODUCT

After the sale is complete, the product must be delivered to the customer. Nearly all industrial sales (sales by the manufacturer to wholesalers and retailers) involve delayed delivery. The salesperson completes the sale first. Sales orders are then completed and sent to the sales office of the manufacturer. This action starts a four-step process:

1. The sales order is received.
2. An invoice (shipping order and bill) is prepared.



Fig. 23-24. Customers are the key to the success of companies. Customer purchases provide the money to pay all company expenses and profits. (Ohio Art Co.)

3. Goods are packed and shipped.
4. Finished goods inventory records are adjusted to show the products shipped from the warehouse.

SUMMARY

Marketing is the key to company success. Products must be promoted, sold, and distributed, Fig. 23-24. To insure that this happens, many companies constantly refine and improve their products and marketing efforts to increase sales.

The goal of all of this activity is to retain present customers and to attract new customers. Their purchases provide the money necessary to pay salaries and wages, buy materials and equipment, develop new and improved products, and keep the company competitive.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

advertising agency
brand name
company or idea advertising
comprehensives
copy
copy platform
inventory turn
layout
marketing mix
maximum profitability point

packaging
product advertising
sales call record
sales order
story boards
trade name
trademark

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. List the six essential tasks necessary for effective marketing.
2. A good trademark, like a product name, should be:
   a. Easy to see and recognize.
   b. Adaptable for advertising and packaging.
   c. Timely and in good taste.
   d. All of the above.
3. True or False? Product advertising promotes the company in general or an idea.
4. Name the three stages involved in developing advertisements.
5. List three major criteria a package should meet.
6. True or False? The best selling price is not necessarily the one that moves the most products.
7. The basic factor in determining the profitability of a company is a sound product _____ policy.
8. Which of the following must sales personnel know?
   a. The product.
   b. The competition.
   c. Potential customers.
   d. All of the above.

APPLYING YOUR KNOWLEDGE

1. Collect two samples of advertisements that use emotional appeal and two advertisements that use an appeal to logic.
   a. Look for the examples in newspapers and magazines. Clip out those you like. (Be sure you have permission to clip.)
   b. Prepare forms like those shown in Fig. 23-A.
   c. Attach each form to the appropriate advertisement.
   d. Share your advertisements and completed forms with the class and discuss the effectiveness of each advertising approach.
2. Pretend that you have been hired as an advertising designer. Your first task is to develop an advertisement for "NATURE SOAP," which is an aloe-based liquid bath soap, that is sold in a plunger dispenser. The slogan for the product is "NATURE knows its business." Prepare copy, a layout, and a comprehensive for the advertisement.
3. The product described above will be displayed on supermarket shelves. Design a package that will make displaying the product easy and effective. Show both the layout and graphics for the package. If you have time, make a prototype (model) of the final package.
4. Prepare a sales presentation that could be used to sell the above product to distributors (wholesalers and retailers) and retail customers.

EMOTIONAL
To what emotion is the advertisement directed? _____ _____
How is the appeal presented? _____ _____
Would the advertisement cause you to buy the product? _____ _____

LOGICAL
What features or information are stressed in the advertisement? _____ _____
How are the features or information presented? _____ _____
Would the advertisement cause you to buy the product? _____ _____

Fig. 23-A. Prepare forms similar to these on which to record your evaluations of the advertisements you will analyze.

24

CHAPTER

MAINTAINING FINANCIAL RECORDS

After studying this chapter, you will be able to:
- *Describe the cash flow of a typical manufacturing enterprise.*
- *List the four basic areas about which company financial records provide information.*
- *Define the term "net profit."*
- *Explain the difference between a balance sheet and an income statement.*

We all handle money as a routine part of our lives. We may get it as pay for work we do, as a gift, or as interest from a savings account. Money is what we use to pay for the things we need.

Many people keep records of the money they handle. They project the **income** they expect. They also record each item of **expense**. This gives them an idea of where their money came from and where it went. It also allows them to see if money was spent unwisely or in excess. Financial records give them a picture of what it costs to live.

CASH FLOW IN A MANUFACTURING ENTERPRISE

Manufacturing enterprises also handle money. They have income and expenses. They need money to buy materials, pay wages and salaries, and purchase equipment and services. They also have to pay taxes and provide for dividends (shares of profits) to the company's investors. A company's money-handling activities, of course, are far more complex than those of a family or individual. Fig. 24-1 is a simple **cash flow** chart. It shows the basic elements of a company's income and expenses.

Start with the *enterprise's cash* in the lower left corner of the chart. It is easy to see that money is coming in from three sources:
- Sales of products *(sales income).*
- Investment from owners *(equity financing).*
- Loans from lenders *(debt financing).*

WORKING CAPITAL

This money makes up the **working capital** of the enterprise. It is used to pay the costs involved in making products. These include payments for plant and equipment (**capital resources**), materials and supplies (from natural resources), natural gas and electricity (energy resources), and wages and salaries (human resources).

Along the way, there are "shrinkages." These are points at which money leaves the cycle without advancing it. The money never returns to help the company grow or develop new products. These points include losses from bad debts (products ordered and shipped but not paid for), tax payments, interest and principal payments on loans, and dividends for investors.

MONITORING MONETARY ACTIVITIES

As you can see, financial managers must monitor various types of monetary activities. They must be sure that sales income meets product design, production, and marketing expenses. They must cut nonessential expenses as much as they can. Selling a product for enough money to meet only labor and material costs is not adequate. Sales income must also be high enough to make tax, interest, and principal payments. Only then can a company be profitable and pay investors a dividend.

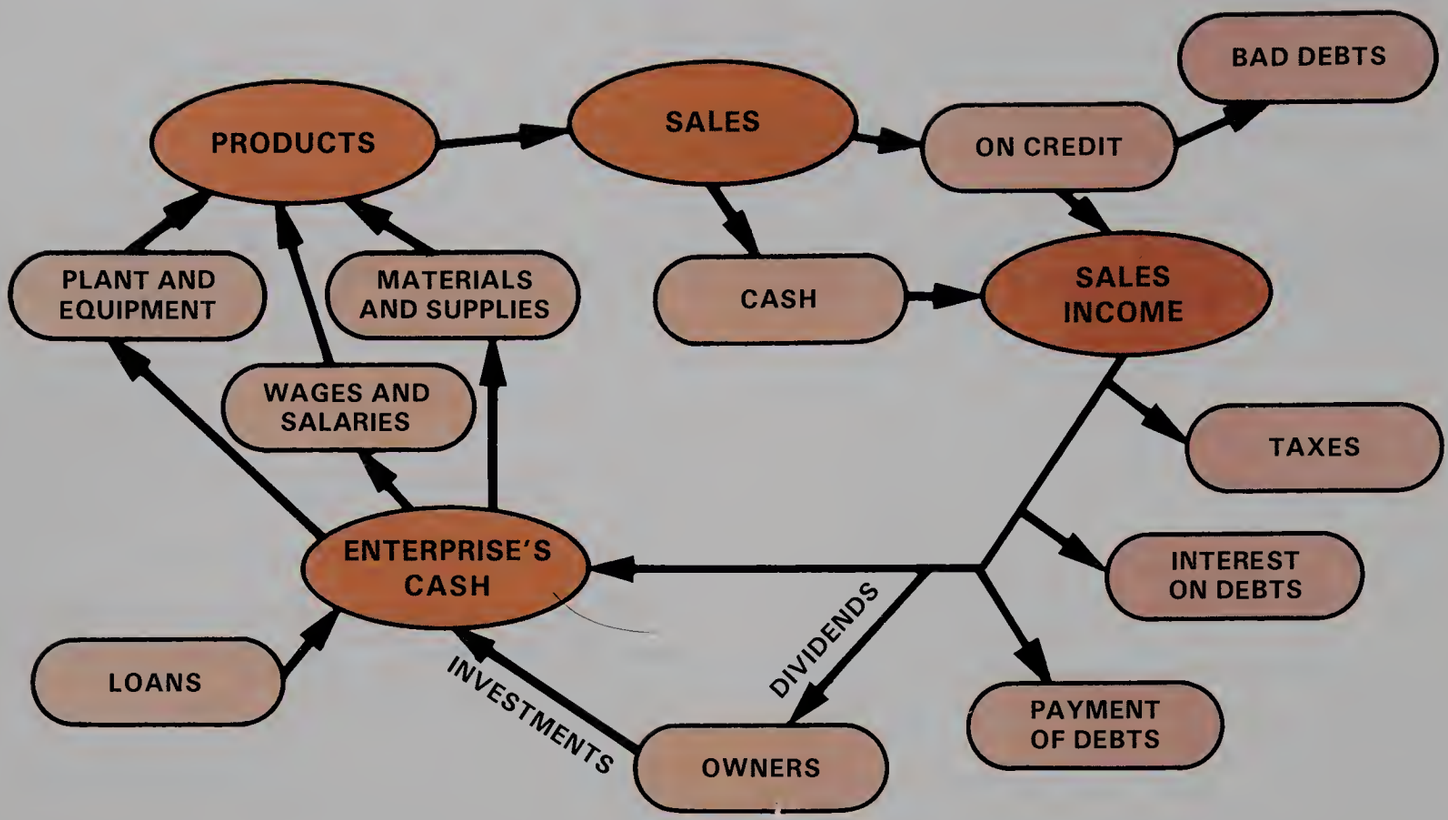


Fig. 24-1. This simplified cash flow chart shows typical income and expense items for a manufacturing enterprise.

FINANCIAL ACCOUNTING

In a manufacturing enterprise, the flow of money is ongoing, Fig. 24-2. It flows *in* as products are sold. It flows *out* to pay expenses. Financial managers keep a series of records to monitor the income and outgo of money. These records are often called *the company's books*. They provide the data that managers need to effectively control costs and assure profitability. The process of maintaining financial records is called **accounting**.

Accounting involves two basic tasks. The first is *maintaining financial records*; the second, *preparing financial reports*. The records preserve and summarize the financial transactions of the company. Reports show the effects of those transactions on company activities.

RECORD-KEEPING SYSTEMS

All accounting is based on use of a record-keeping system. There are many such systems available. Each

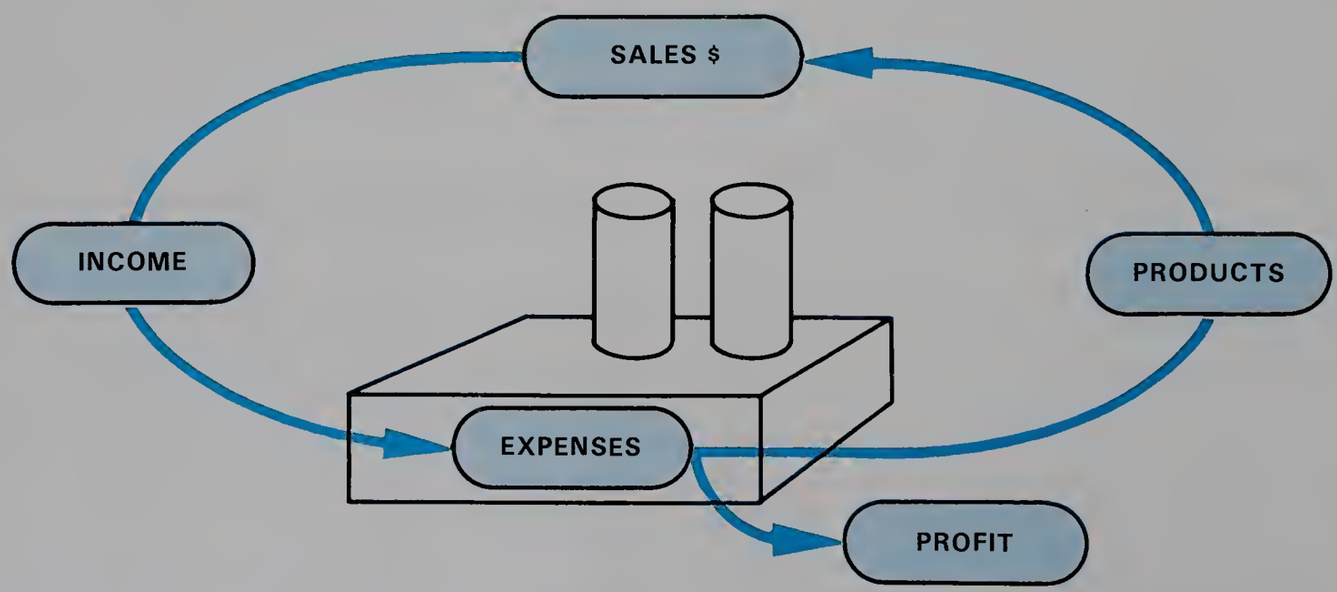


Fig. 24-2. Financial records register the movement of money into and out of a manufacturing enterprise. Income from product sales is used to pay expenses and provide dividends to the investors.

company will use the one that best fits its operations and financial record-keeping needs. All these systems are designed to:

- Allow quick and easy data entry and summarizing, Fig. 24-3.
- Present financial data in a logical, easily understood format.
- Provide data that can be used to help make sound management decisions.

Company financial records provide information in four basic areas. These are:

- **Net income** earned during a period of time. Total income minus expenses equals net income.
- Total value of all **assets** of the company. Assets are items of value owned by the company. Typical assets include plant, equipment, inventory (materials, work-in-progress, and finished products), and patents.
- The **liabilities** owed by the company. Liabilities are debts that the company owes its suppliers, employees, and lenders.
- The **net worth** of the enterprise. Assets minus liabilities equals net worth. A company can have a *negative* net worth–it can owe more money than it has assets.

PREPARING FINANCIAL RECORDS

Most accounting systems are based on a **general ledger**, Fig. 24-4. This record contains information on all financial transactions of the company. Basically it is a record of all money coming in (**credits**) and all money paid out (**debits**).

Maintaining a general ledger

To maintain a general ledger, an accountant enters the date and describes the transaction. The dollar amount is then entered in the proper column. All income from rental or sale of assets is entered in the *credit* column. These may be products, services, equipment, patents, copyrights, or other assets. Any expenses for materials, labor, or capital resources are entered in the *debit* column.

AJAX MANUFACTURING COMPANY, INC.
GENERAL LEDGER

DATE	DESCRIPTION	DEBIT	CREDIT

Fig. 24-4. Companies use a general ledger to record all income and expenses for the business.



Fig. 24-3. Computer-based accounting systems allow for quick data entry and rapid generation of reports.

At regular intervals, the accountant totals the ledger's credit and debit columns. To measure a company's financial strength, she or he then subtracts the total of the debit column from the total of the credit column. If the remainder is a positive number, the company made a profit during the reporting period. A negative number indicates that the company lost money during that period.

This type of report may be prepared daily, weekly, monthly, quarterly, or yearly. To show long-term financial performance, results for various years can be compared.

Cost accounting ledgers

Managers often want financial reports that have greater detail. To provide more information, accounting records can be kept using specific ledgers for each major cost item. The cost elements for a manufacturer might be broken down this way:

EXPENSE ACCOUNT NO.	DESCRIPTION
01	Direct labor
02	Indirect labor
03	Supervision and clerical labor
04	Direct materials
05	Indirect materials
06	Utilities
07	Administrative labor
08	Marketing labor
09	Marketing material and supplies
10	Maintenance labor
11	Maintenance materials

In the same way, a company with many products may keep ledgers for each one. Sales income is entered in the ledger for the specific product. All direct and indirect costs involved in developing, manufacturing, and marketing that product are recorded in the same ledger. This type of record-keeping is called cost accounting. The cost of producing each specific product can be determined. This cost can then be compared to the income produced by each product in the company's line. Management can use this information to decide which products are doing well and which ones should be redesigned or dropped from the line.

Profit centers

Cost accounting records can be kept for a specific product (lawn mower), a line of products (lawn and garden equipment), a single factory (New Jersey engine plant), a department within a plant (riding mower assembly), or a group of plants (outdoor products division), Fig. 24-5. Each unit chosen for cost accounting is called a **profit center**. Management expects each of them to contribute to the company's overall profitability.

PREPARING FINANCIAL REPORTS

Accounting records provide the data needed to produce periodic financial reports. These reports answer the question: *"How is the company doing financially?"* That answer is often the basis for important decisions.

Financial reports convey useful information to a number of audiences. These include:

- *Managers within the company.* They make vital employment, purchasing, product development, production, and marketing decisions based on financial data, Fig. 24-6.
- *The company's public relations and financial affairs managers.* They use financial data to direct and promote company policies.
- *The company's stockholders.* They read quarterly and annual financial reports to determine how well their investment is paying off.
- *The company's creditors.* **Creditors** read the reports to assess the safety of loans made to the company and to see if the company is complying with loan terms.
- *Local, state, and federal government.* Agencies of government use company financial reports to determine taxes due. They may also use the information in reports to predict the economic health of a particular area or the entire country.

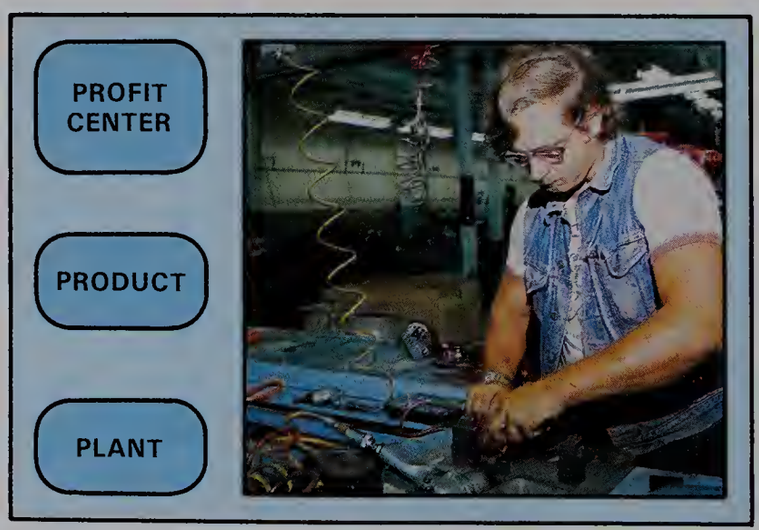


Fig. 24-5. Cost accounting maintains a separate ledger for each profit center. A profit center can be a specific product, a product line, an entire factory, a single department within a plant, or a group of plants. (The Toro Co.)



Fig. 24-6. Financial records help managers make decisions about product development, engineering, and production activities. (General Motors Corp.)

- *The general public.* Individuals use financial reports to gain knowledge about companies and to help them make personal investment decisions.

Types of financial reports

There are various types of financial reports. The two most important are the **balance sheet** and the **income statement**.

Each of these provides a *partial* picture of the company's fiscal health. The balance sheet gives a financial picture for a *specific date*. The income (profit and loss) statement summarizes financial transactions over a *specific period of time*.

The balance sheet answers the question: *"How much is the company worth at this point in time?"* The income statement shows the company's profits or losses for a specific *time span*. Neither report gives the total financial picture. Taken together, though, they provide a reasonable basis for judging the company's financial health.

Balance sheet

A balance sheet shows the assets, liabilities, and net worth of the company *on the day it was prepared*. A balance sheet is prepared from information in the general and cost accounting ledgers.

A simple balance sheet is shown in Fig. 24-7. At the top, it lists all of the assets held by the company. They include:

CURRENT ASSETS

- Cash and marketable securities: the money in various bank accounts and the value of common stock and bonds owned by the company.
- **Accounts receivable:** the money owed the company by customers who have purchased products and services.
- **Inventory:** the value of materials, work-in-process, and finished goods owned by the company.

EXETOR CORPORATION
Balance Sheet - December 31, 19xx

Assets	
Current assets:	
Cash	$ 8,171
Short-term investments	42,147
Accounts receivable	78,127
Inventories	136,885
Total current assets	265,340
Land and buildings	253,538
Plant and equipment	677,009
Other assets	23,696
	$ 1,219,573
Liabilities and Stockholders' Equity	
Current liabilities:	
Accounts payable	$ 126,019
Current installments on long-term debt	12,895
Total current liabilities	138,914
Long-term debt	344,312
Deferred taxes	161,781
Stockholders' equity	574,566
	$ 1,219,573

Fig. 24-7. A company's balance sheet lists the assets, liabilities, and net worth of the business on a given day.

FIXED ASSETS

- Land and buildings: the value of real estate owned by the company.
- Plant and equipment: the value of the means of production owned by the company.
- **Goodwill:** the value of the "good name" of the company and its products, as well as the value of patents and trademarks it owns.

The liabilities for the company are listed next. The main types are:

CURRENT LIABILITIES

- **Accounts payable:** money owed to the company's suppliers for material and to its employees for work performed.
- Other debts payable: the interest and principal payments due this year on the company's long-term debt.

FIXED OR LONG-TERM LIABILITIES

- **Long-term debt:** money owed to creditors that is to be paid over a period longer than one year.
- **Deferred taxes:** taxes due on money earned to date, payment of which has been legally postponed to a later date.

Finally, the **stockholders' equity** is determined. This is the actual value of the *investors' share* of the company. It is found by subtracting the company's liabilities from its assets. The value of the stockholders' equity is often called the net worth of the company.

In rare cases, net worth can be a *negative* number. This means there is no real value behind each share of stock; the company is probably near collapse.

A company's balance sheet will provide answers to the three basic questions shown in Fig. 24-8. These questions are:

- *"How much are our assets worth?"* What is the value of all the tangible and intangible items the company owns?
- *"How much do we owe our suppliers, creditors, and employees?"* What debts does the company have (including taxes owed the government)?
- *"What is the value of the company to our stockholders?"* How much value is there behind each share of ownership?

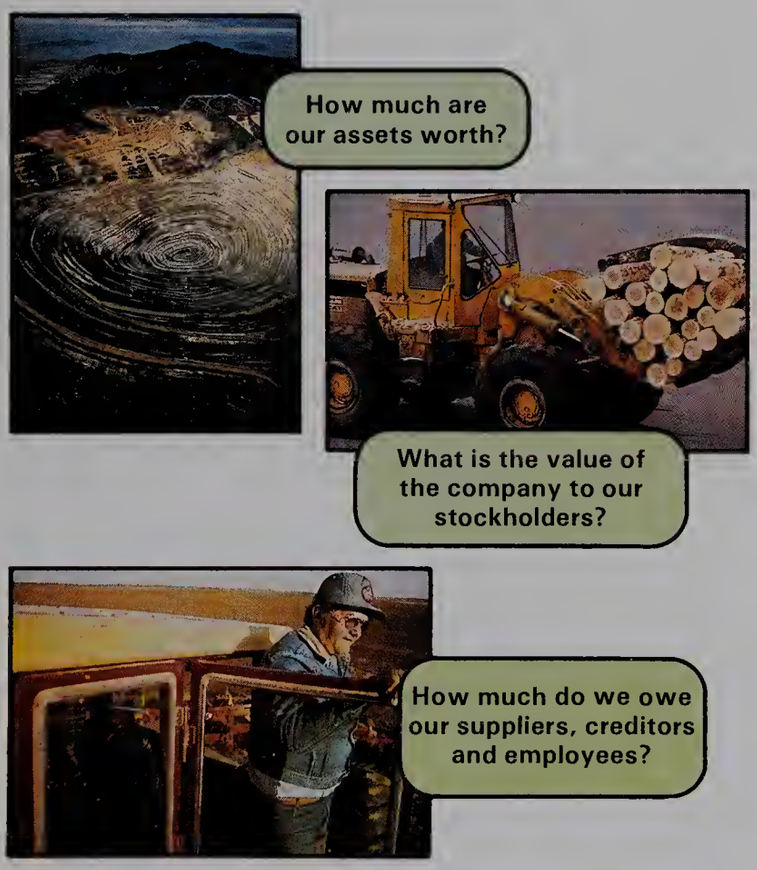


Fig. 24-8. A balance sheet provides the answers to these basic questions about a company.

Income statement

A balance sheet is like a snapshot of the company's financial health. It *stops action* at a given point for a view of all assets and liabilities.

By contrast, an income statement *tells a story*. It describes what has happened financially to the company over a period of time. It shows financial action. If a balance sheet is a *still* photo, the income statement is a *motion picture*.

An income statement is shown in Fig. 24-9. It lists the company's income, expenses, and profit or loss over a period of time. This could be a month, a quarter, a year, or a five-year period.

An income statement is also referred to as a **profit and loss statement** or, for short, a "P & L." Some specific terms used to discuss information on an income statement include:

- Income: money received for products and services sold by the company.
- Expenses:
  a. Cost of goods produced, including direct materials and labor.
  b. Costs involved in administering the company and selling its products.
  c. Depreciation (declining value due to age) of plant and equipment.
- Operating profit: income minus expenses (not including interest and tax payments).
- Income before taxes: income minus expenses and interest payments.
- Net income: income minus all costs (expenses, interest payments, taxes). This term is the same as **net profit**.

The income statement summarizes the flow of money into the company, the cost of creating this

EXETOR CORPORATION
Profit and Loss Statement - 19xx

Net Sales	$ 950,323
Costs and expenses:	
Material, labor, and other operating expenses	747,698
Depreciation	61,225
Selling, general, and administration expenses	61,003
	869,926
Earnings from operations	80,397
Interest expense	(30,958)
Interest and dividend income	5,820
Earnings before taxes on income	55,259
Provisions for taxes on income	17,590
Net earnings	37,669
Preferred dividends	4,819
Net earnings available for common stockholders	32,850
Earnings per common share	$ 1.10

Fig. 24-9. An income statement shows what has happened to a company financially over a period of time.

flow, and the profit or loss resulting from the company's operations.

Quarterly and annual reports

The income statement and the balance sheet are essential parts of a company's reports to its stockholders. Most companies produce two types of these reports: quarterly and annual. The quarterly report briefly describes the company's operations and gives financial data for the latest *quarter* (three-month period).

The **annual report** is more detailed. It is designed to communicate both the company's "image" and more complete financial data. The actual message and its format varies from company to company. A good annual report will contain at least the following sections:

- A brief *financial summary* that presents an overview of the current year and compares it with previous years.
- A *message to stockholders* from the president and/or chairman of the board. The message provides a summary of the company's successes and challenges.
- A *narrative section* that spotlights specific company operations or products.
- Detailed *financial reports* that present the financial operations of the company, its major divisions, and/or major product lines.
- *Historical financial data* that tracks sales, expenses, and income for a period of time, usually five or ten years.
- A listing of major company officers and the members of the board of directors.

The annual report provides an accurate, factual picture of the company. The report is often the main avenue of communication between a corporation's management and its stockholders. For this reason, it should be attractive and easy to read.

SUMMARY

Accurate financial information is vital for proper management of any business. Managers must know how much money is coming in from sales and how much is being used for company operations. This data is collected and recorded through general and cost accounting systems. It is summarized on two basic financial documents: the income statement and the balance sheet. These documents, in turn, are the basis for the company's annual report to its stockholders.

KEY WORDS

All the following words have been used in this chapter. Do you know their meanings?

accounting
accounts payable
accounts receivable
annual report
assets
balance sheet
capital resources
cash flow
creditors
credits
debits
deferred taxes
expense
general ledger
goodwill
income
income statement
inventory
liabilities
long-term debt
net income
net profit
net worth

profit and loss statement
profit center
stockholder's equity
working capital

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. What are the three sources of the money that makes up the *working capital* of a business?
2. List the four basic areas about which company financial records provide information.
3. Which of the following are considered *assets* of a company?
   a. Inventory.
   b. Accounts payable.
   c. Plant and equipment.
   d. Cash.
   e. Patents and trademarks.
   f. Deferred taxes.
4. Which report is a picture of the company's financial situation on a *specific date*, the income statement or the balance sheet?
5. True or False? The terms "net income" and "net profit" mean the same thing.
6. Which report listed below usually includes a message from the company's president or board chairman?
   a. Balance sheet.
   b. Annual report.
   c. Income statement.
   d. Profit and loss statement.

APPLYING YOUR KNOWLEDGE

1. Develop a personal cash flow chart.
   a. Make a list of your income sources (gifts, part-time job, etc.).
   b. Make a list of the kinds of expenses you pay out from your income (clothing, entertainment, gasoline, etc.).
   c. Use the information from your income and expense lists to make a chart similar to the one shown in Fig. 24-1.
2. Prepare an outline and develop a format for the annual report of a club or a church group.
3. Use pictures cut from magazines or newspapers to prepare a "balance sheet" bulletin board. The pictures you choose should show the common types of assets and liabilities for a manufacturing company.

25

CHAPTER

CLOSING THE ENTERPRISE

After studying this chapter, you will be able to:

- *List a number of reasons why a business might face dissolution.*
- *Explain the four-step process involved in dissolving a company.*
- *Define the term "severance pay."*
- *Describe the order of payment (priority) for claims on the dissolved company's cash.*

A company is a living entity. It develops, manufactures, and markets products to meet the needs and wants of people. The company must do this efficiently if it is to make a profit and survive.

Sometimes, a company is unable to make a profit. At other times, the company may be profitable, but the owners may want to take their money out of it. In either situation, the company must cease operation.

DISSOLVING THE COMPANY

Each year, thousands of companies outlive their usefulness, Fig. 25-1. They must be shut down in an orderly manner. Their assets must be changed into cash to pay debts. If possible, some cash is also used to return the owners' investments.

The process of closing down a business is called **dissolution**. A company may face dissolution for any of several reasons:

- **Bankruptcy** (inability to pay its debts.)
- Unprofitability, that would lead to bankruptcy, if continued.
- Sale of assets (plants, product lines, etc.), leaving only a *corporate shell* with no continuing business operations.
- Refusal of the state to renew a corporation's charter when it expires.
- Revocation of a corporate charter by the state because of illegal operations.
- Decision by the board of directors and stockholders to liquidate the corporation.

To dissolve a corporation, the officers must complete several important tasks. If the company is a partnership or a sole proprietorship, the partners or single owner must complete most of the same tasks. They include:

- Filing the proper documents.
- Terminating (releasing, laying off, retiring) the employees.

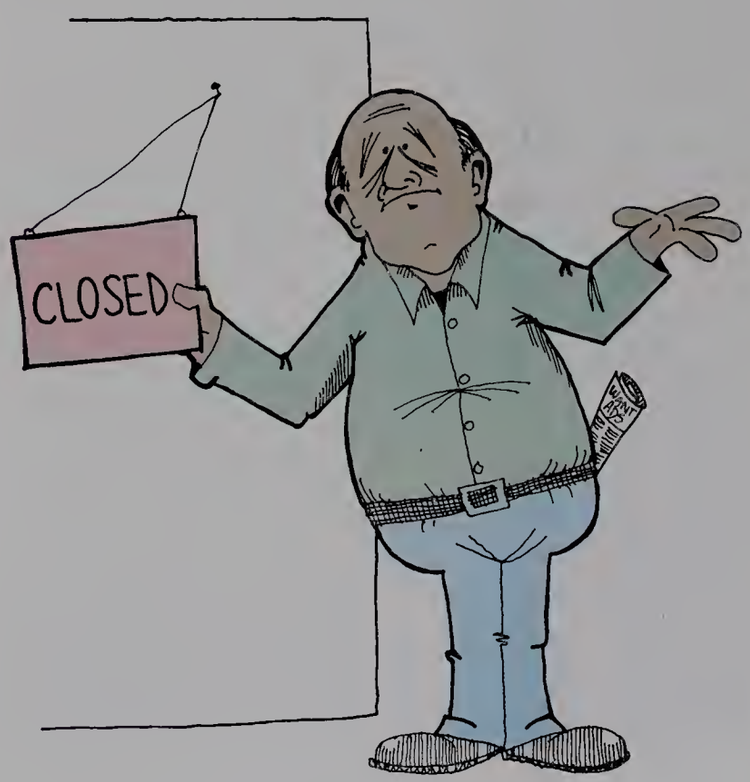


Fig. 25-1. For a variety of reasons, thousands of companies close their doors each year.

- Converting all assets into cash.
- Distributing the cash according to the legal rights of creditors, employees, government agencies, and owners.

When these tasks are finished, the company is officially dead. In the case of a corporation, the charter is withdrawn; the company passes from the economic scene.

FILING LEGAL DOCUMENTS

Two basic legal acts can cause a business to dissolve, Fig. 25-2. The first is filing articles of dissolution. This is a voluntary procedure. The second is an *involuntary* procedure: a court order obtained by a company's creditors (holders of debt).

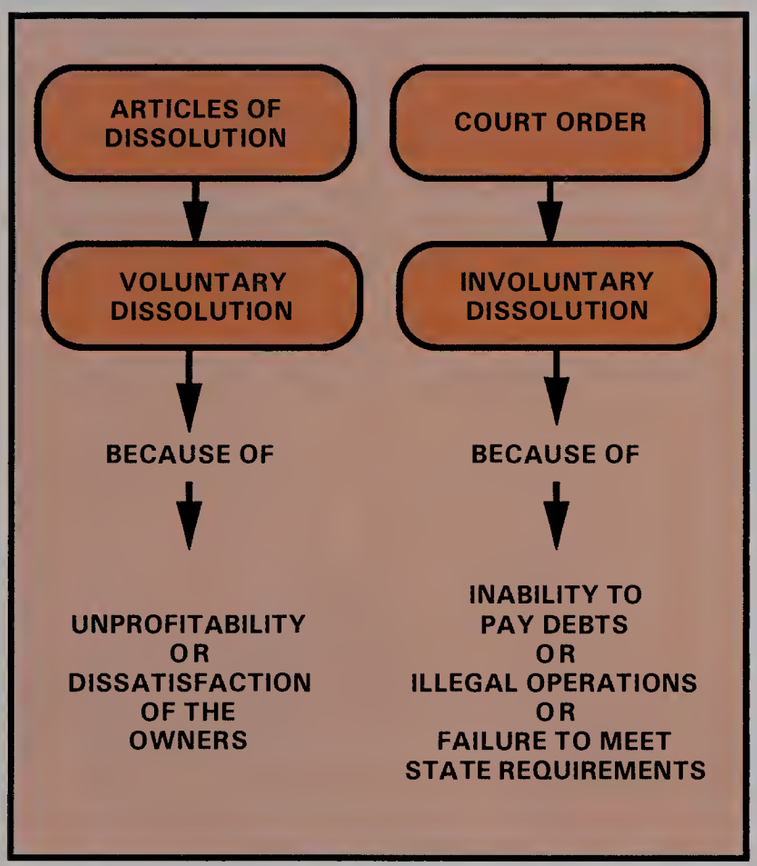


Fig. 25-2. Companies may be dissolved voluntarily or involuntarily. The inability to pay debts is the most common cause of dissolution.

Articles of dissolution

Articles of dissolution tell the state that a corporation wants to quit operating. The forms are filed with the same state office that originally issued the articles of incorporation.

Owners must take action to shut down a corporation. At an official stockholders' meeting, they must approve a motion to dissolve the company.

Court-ordered dissolution

The second type of legal action that may be used to dissolve a business is a **court order**. Creditors may ask a state court to order the company to stop operating and sell off its assets. This is often done when a company fails to pay its bills or can't meet interest and principal payments on loans, Fig. 25-3. Government agencies or individual stockholders may seek court action if they feel the company is violating laws or its corporate charter.

A court-mandated (involuntary) dissolution is called bankruptcy. It provides for proper distribution of the cash generated from sale of the company's remaining assets.

TERMINATING EMPLOYEES

The first step in closing a manufacturing company is to stop making products. This requires shutting down plants and terminating the employees who work in them.

Workers may be **laid off** at any time in the life of a company. Layoffs occur when production is cut back, or when automation reduces the need for machine operators. Such layoffs may be temporary or *permanent*. Also, workers who cannot adjust to company rules and policies are often *fired*.

When a company is dissolved, though, the entire work force is let go sooner or later. Production workers and product development people go first. Warehouse workers and salespeople are next. The last employees to leave are usually the top managers and accounting personnel.



Fig. 25-3. If a company fails to pays its debts or loan obligations, it may be forced into bankruptcy.

Termination notices

Employees will probably receive a **termination notice**. It tells them that the company no longer needs their services. Such a notice can be issued at any point in a company's life-its use isn't restricted to closing of the business. A typical termination notice contains this information:

- Type of termination: resignation, retirement, release (firing), temporary layoff, permanent layoff.
- Reason for termination.
- Recommendation for rehiring (If the company is not being dissolved.).
- Whether severance pay will be paid.

A terminated employee usually is checked out of the company. Company property is returned and marked off a termination checklist.

All such employees should receive their last paycheck and any severance that is due. **Severance pay** is a special allowance often paid to workers who lose their jobs. It helps meet living expenses until the worker finds another job or receives unemployment insurance payments.

CONVERTING ASSETS INTO CASH

Terminating and paying the work force clears the way for the next dissolution step: converting assets into cash. The company no longer needs its assets. Instead, it must have *cash* to pay its bills and to return money to its investors.

Types of assets

Typically, a company has four basic types of assets that can be sold. These are, as shown in Fig. 25-4:

- Materials in inventory.
- Technical information, including product plans, patents, trademarks, and customer lists.
- Plant, equipment, and tooling.
- Finished goods.

The company will most often try to sell its assets intact. That is, they will try to sell the entire business in one transaction. If a single buyer cannot be found, assets will be sold separately.

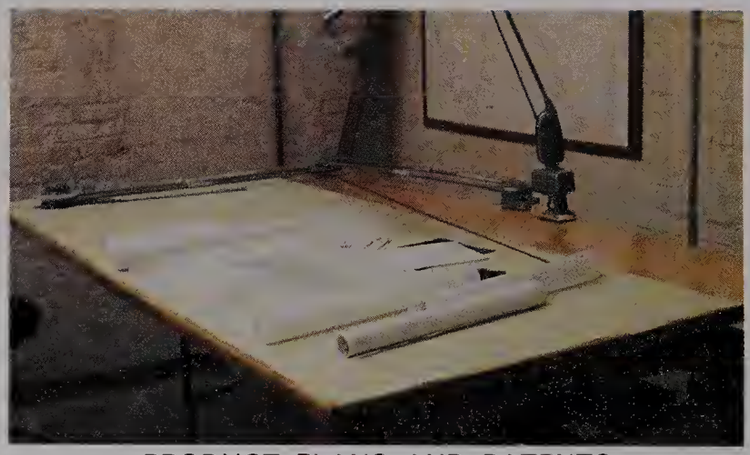
Assets may be sold at a fixed price, at a price negotiated with each buyer, or at auction, Fig. 25-5. Once all assets are sold, a final balance sheet is prepared. It will show the net worth of the company.

DISTRIBUTING CASH

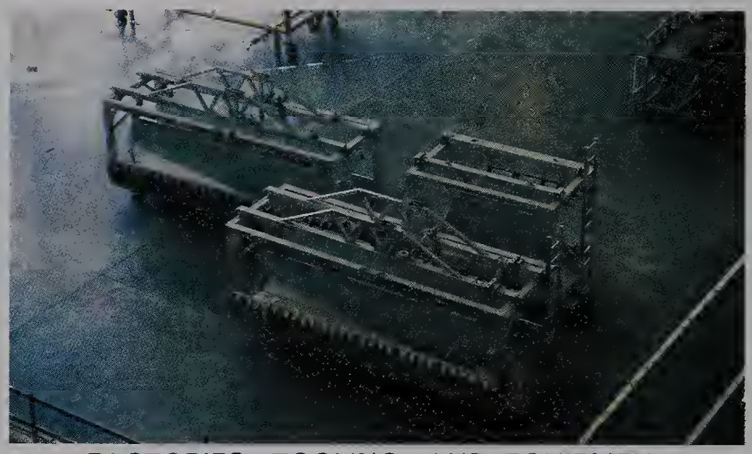
The last step in dissolving the company is to pay as many debts as possible. In some cases, there will be



MATERIALS



PRODUCT PLANS AND PATENTS



FACTORIES, TOOLING, AND EQUIPMENT



PRODUCT INVENTORY

Fig. 25-4. A company has many different types of assets that can be sold when it is dissolved.

enough cash to return the investments of the owners. Most dissolutions, however, result from a lack of operating funds. This means it is unlikely that all creditors will receive full payment for their claims. It is even less likely that the owners will receive payment for their stock.

Priority of claims

Most states have laws that dictate the priority of various claims on the company's cash. These laws specify who should be paid first, second, and so forth. The usual order of payment is shown in Fig. 25-6. Priorities are:

1. Taxes.
2. Legal costs of the dissolution process (state filing fees, attorney's fees, court costs, etc.).
3. Wages and salaries owed to employees.
4. Creditors.
5. Owners (investors).

As you'll remember, entrepreneurs were defined in an earlier chapter as "people who were willing to take a *risk* in forming a company." Since owners have last claim on the cash, you can see that this risk may include *losing* the time and money invested in the enterprise.

SUMMARY

Not all companies succeed. Some fail to meet their expenses or return as much profit as the owners expected. These companies may be closed and all operations ended. This action is called dissolution. It can be a *voluntary* action by the owners. It may instead be *involuntary*, resulting from *legal action* by creditors or government officials.

The end result is closing down of the business. As noted earlier, a company is an *artificial being*. It can be born, live (produce products and services), own assets (land, materials, etc.) and die. Dissolution is the official death of the company.

KEY WORDS

All the following words have been used in this chapter. Do you know their meanings?

bankruptcy
court order
dissolution
laid off
severance pay
termination notice



Fig. 25-5. Assets of a dissolved company are frequently sold at auction.

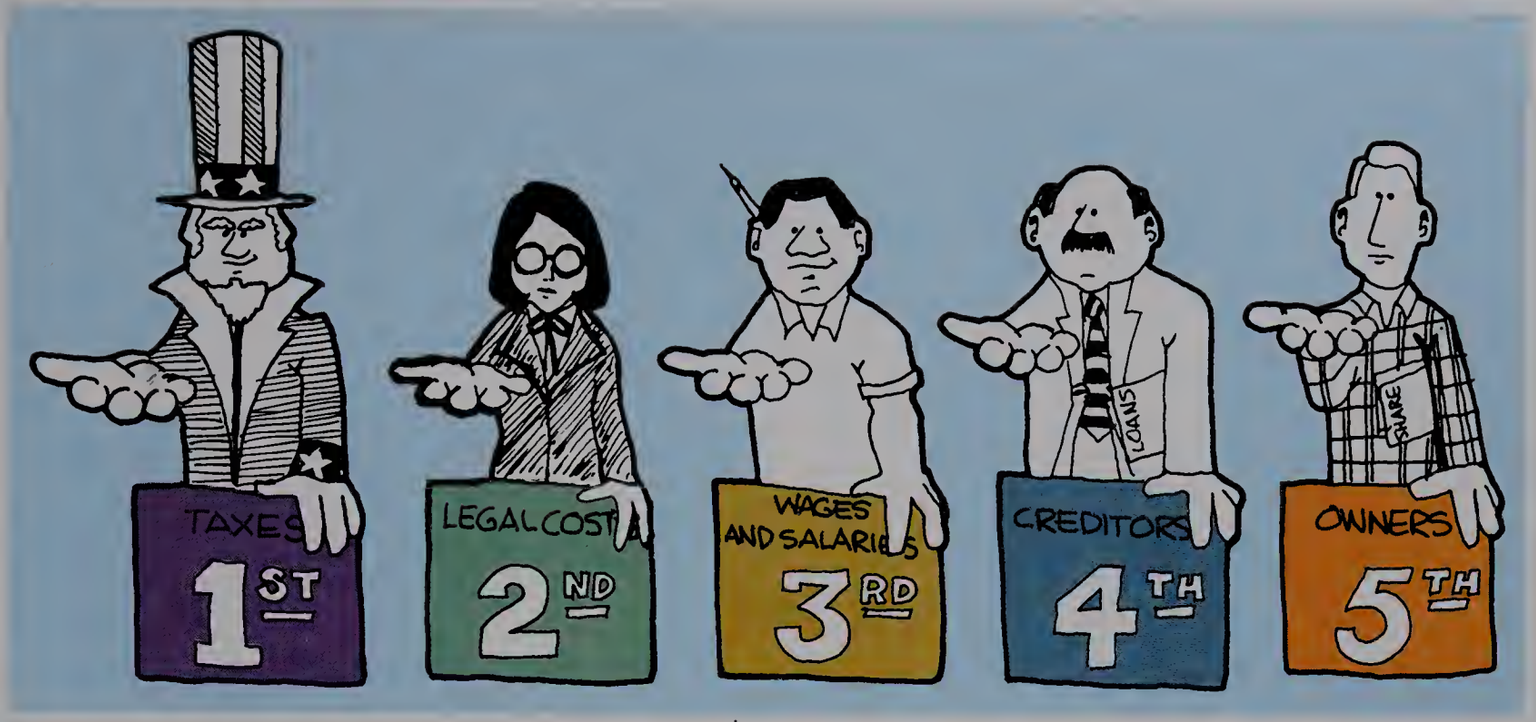


Fig. 25-6. Claims are paid in a definite order when a company is dissolved.

TEST YOUR KNOWLEDGE

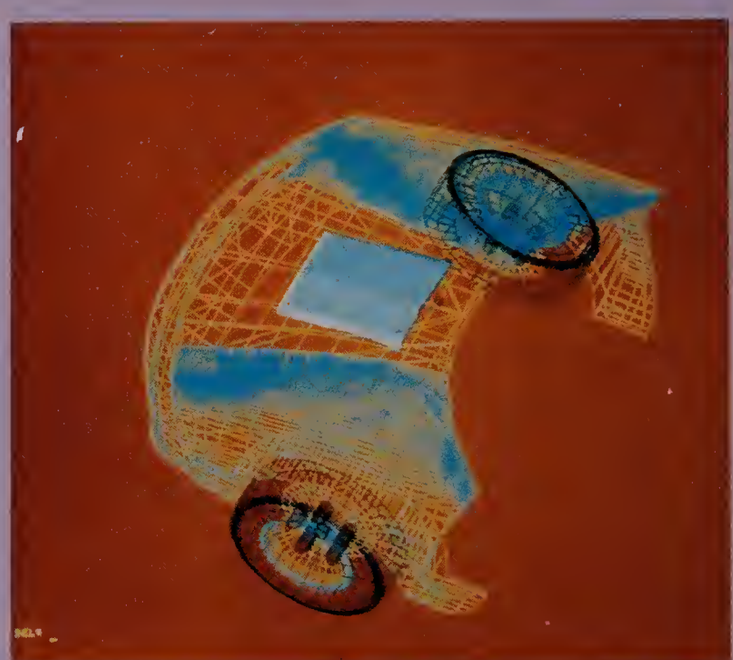
(Please do not write in this text. Place your answers on a separate sheet.)

1. Articles of dissolution are _____ means of starting the process of closing down a company.
2. A company that no longer has any assets is known as a:
   a. Bogus corporation.
   b. Dead business.
   c. Corporate shell.
   d. Leveraged buyout.
3. List the four major steps in dissolving a company.
4. True or False? An individual stockholder can seek a court order to dissolve a corporation.
5. Which of the following groups of employees is usually the *last* to be terminated when a company is dissolved?
   a. Accounting personnel
   b. Salespeople
   c. Warehouse workers
   d. Production workers
6. Taxes and legal costs are the first two priorities for payments when a dissolved company's cash is distributed. Which group will be paid next–owners, employees, or creditors?

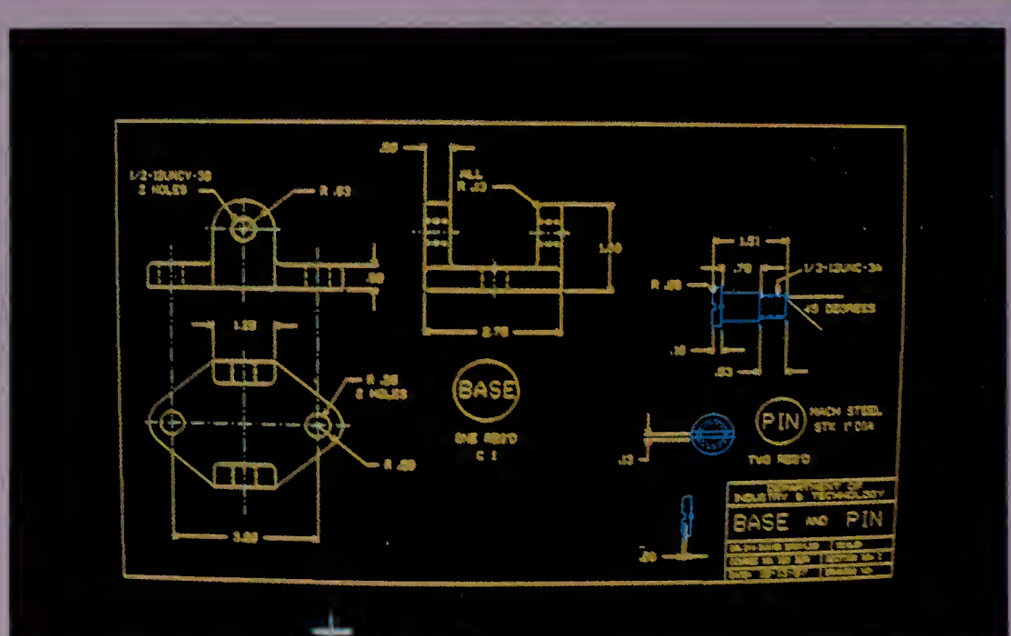
APPLYING YOUR KNOWLEDGE

1. Prepare a buletin board display on the dissolution of a company.
   a. Check a newspaper from a large city for advertisements on auctions of industrial equipment. (These are often listed under the name of a company.)
   b. Try to determine why the equipment is being sold. (Often, this is stated: going out of business, lost lease, etc.)
   c. Build your display around the advertisement. (Suggestion: look in magazines for photos of the type equipment being sold.)
2. Take the books from a model enterprise and list the expected value of all its assets and liabilities. Should the company be liquidated? Why?
3. Assume that an enterprise your class had set up to produce a product is being dissolved. Go through the process described in this chapter.
   a. Develop forms for dissolving the company.
   b. Terminate the employees.
   c. Liquidate the assets. Prepare an advertisement for a sale to auction them off.
   d. Hold a mock auction, using play money or "scrip" you have made.
   e. Pay off the creditors and stockholders.





INTERNATIONAL BUSINESS MACHINES CORP.



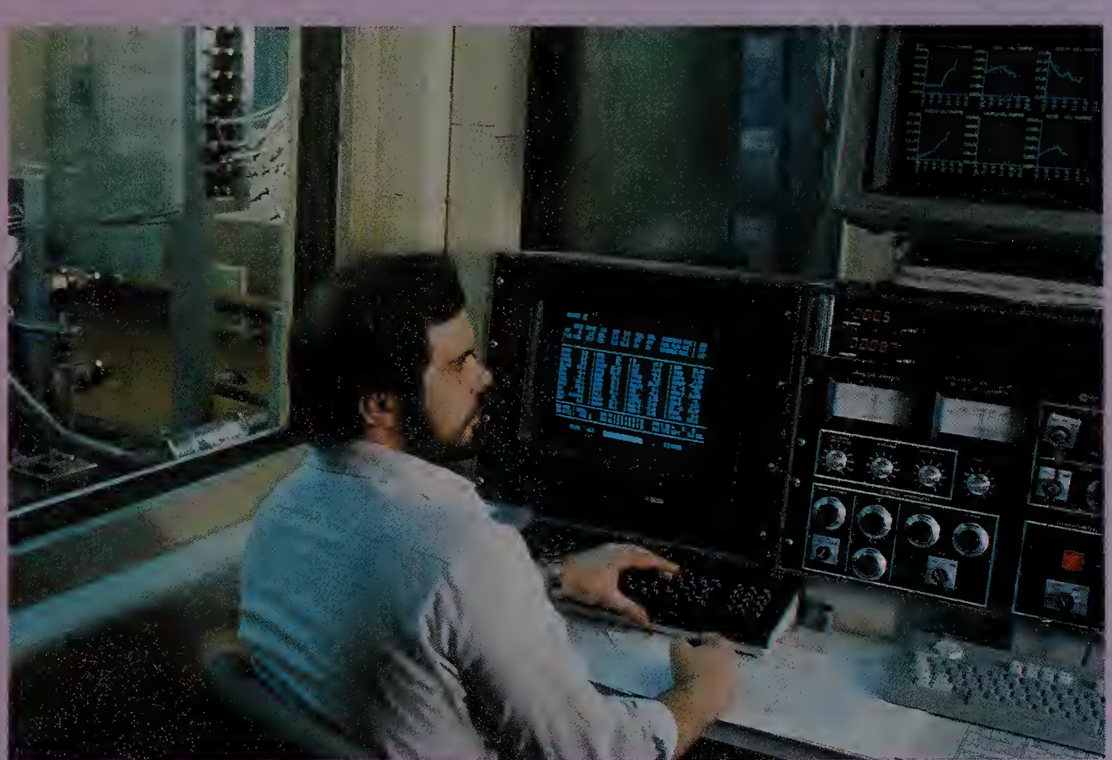
section 6

Automating Manufacturing Systems

26. Automation in Manufacturing

27. Computers and Product Design

28. Computers and Manufacturing



CHRYSLER CORP.



Automation has contributed to the efficiency of manufacturing. This robot is applying undercoat to an automotive wheelwell. (Cybotech)

26

CHAPTER

AUTOMATION IN MANUFACTURING

After studying this chapter, you will be able to:
- *Give a brief history of automation.*
- *Name a device that has revolutionized factory automation.*
- *List five reasons for employing automation.*
- *Name at least three components of CIM.*
- *Explain what CAD and CAM are.*

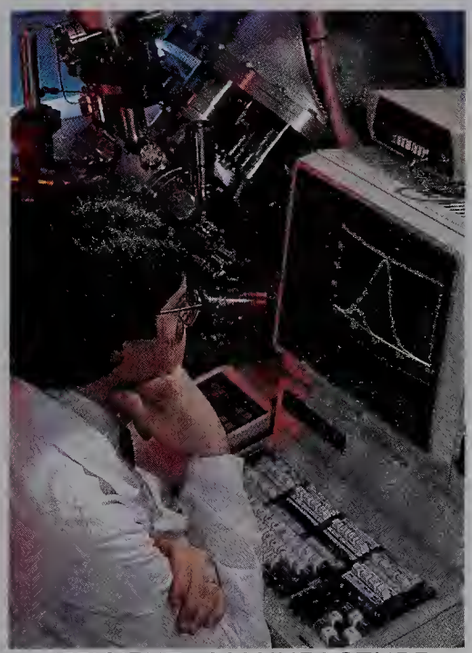
Throughout the history of manufacturing, people have sought more efficient ways to make products. These efforts can be divided into two tasks:
- Designing products for efficient manufacture.
- Making products more efficiently.

Although divided, these tasks are not independent. Often the work of one directly impacts the other. For example, Eli Whitney's work in producing muskets with interchangeable parts required design changes. Musket parts were designed so that all like parts were exactly alike. This way, they could be easily manufactured. The parts were made so that any like part would fit any musket. This enabled the muskets to be assembled more efficiently. Thus, the first task impacted the second.

This interdependence must be addressed if a company is to compete in the world market, Fig. 26-1. Key to this focus is automatic or automated manufacture. Another word for this is automation. **Automation** is the application of control to an apparatus, a process, or a system by means of mechanical or



EFFICIENT DESIGN



EFFICIENT MANUFACTURE



WORLD-CLASS PRODUCT

Fig. 26-1. Manufacturers must develop efficient designs and manufacturing processes to produce world-class products. (American Petroleum Institute, Reynolds Metals Co., Deere and Co.)

electronic devices. Automation is a replacement of direct human control.

DEVELOPMENT OF AUTOMATED MANUFACTURING

It is difficult to trace automated manufacture to any specific event or invention. Ideas for automatic manufacturing machines have many roots.

Early efforts to accomplish automation used strictly mechanical control. One of the earliest attempts in factory automation came around 1800. At that time, ships were experiencing a growing need for blocks (pulleys). The blocks were needed in order to raise and lower sails, move heavy cargo, and position cannons. A typical warship of that age required over 1400 blocks. At that time, each block was individually made by artisans working on lathes, drills, and other machines. In England, Henry Maudslay undertook the task to produce blocks using an automated production line. After six years of hard work, the world saw its first large-scale, *mass production*, manufacturing line. However, mass production did not extend to other industries for another 50 years. Furthermore, its adoption was not in England, but in America. Such a movement, marked by revolutionary changes in production, is called an industrial revolution. This industrial revolution ushered the Western world into what became known as the industrial age.

Even earlier roots of factory automation trace back to mechanized toys. They were developed to entertain members of high society. One such toy, a wooden model of a pigeon designed by Arcytas of Tarentum, dates back to about 350 B.C.

Soon after 350 B.C., Hero of Alexandria began to experiment with pneumatics and hydraulics. He developed a number of water-driven mechanisms including automatic temple doors and singing mechanical birds. His work was applied to many mechanical toys, music boxes, and musical clocks developed in Europe during the eighteenth century. These devices had mechanisms that used *disks*. The disks had ridges or holes that encoded a *program* (detailed operating instructions) that guided the apparatus. The program code held on the disk caused the item to chime or move according to a set plan.

The idea of programmed cards or disks was adapted in 1804 by the French loom maker, M.J. Jacquard. His looms used a series of punched cards to program the machine to automatically produce a set pattern in fabrics and carpets. Later, Herman Hollerith applied this principle to an automatic data-recording and accounting machine. This invention was first used for the 1890 United States census. It reduced the time needed to tabulate the results of the





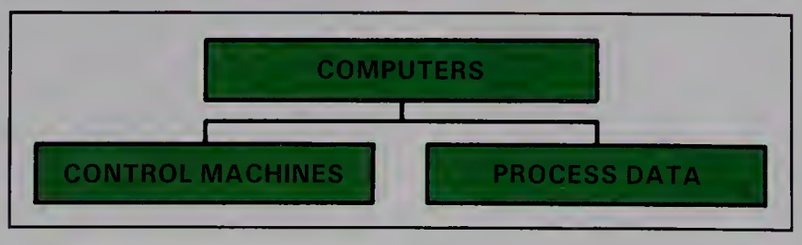


Fig. 26-2. Computers can be used to control machines and processes. They can also process written, graphic, and numerical data. (American Iron and Steel Institute, PPG Industries)

census by 50 percent. His punched cards became the forerunner of the computer card, which was used to enter data in early computers.

In the twentieth century, the idea of a *punched-tape* program was tried on manufacturing machines. These machines, called *numerical control (NC) machines*, became the backbone for the second industrial revolution–the automation age.

The arrival of modern factory automation came with the recent development of the computer. This useful machine is the dominant feature of the computer revolution, which impacts our lives every day. Its advent brought us out of the automation age and moved us into the information age. See Fig. 26-2.

This period in history began in 1945 with the development of the first electronic computer. It was called the ENIAC (Electrical Numerical Integrator and Calculator). From this dramatic start, came the mainframe computer, the minicomputer, and the microcomputer that operate today in almost every facet of the public and private community.

COMPONENTS OF AN AUTOMATED SYSTEM

All efforts to automate manufacturing are guided by a few basic goals. These include:

- Reducing manufacturing costs.
- Increasing product quality and consistency.
- Enhancing manufacturing flexibility.
- Improving marketability of products.
- Reducing the reaction time to changes in market demands.

These goals have caused most manufacturing companies to adopt labor- and material-saving practices, programs, and systems. A number of these are listed in Fig. 26-3. The complexity of the systems increases as they move upward on the chart. The simplest are mechanical, numerical, and computer machine controls. These range from simple tracer lathes to complex, computer-controlled machining centers. The most complex is *artificial intelligence* in which computers are programmed to process data *and* make decisions. This is a radical departure from the normal computer tasks of data processing.

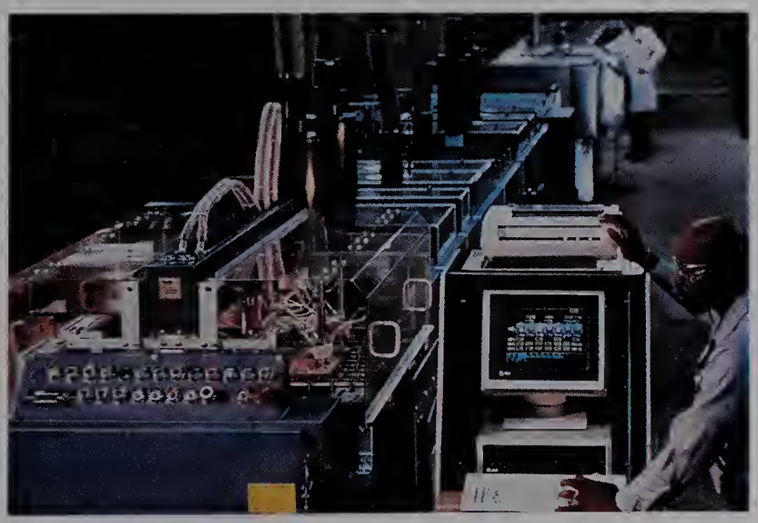
All of the various components of Fig. 26-3 make up a package called **computer-integrated manufacture (CIM)**. CIM is defined by the National Research Council as all activities from the recognition of a need for a product; through the conception, design, and development of the product; and on through production, marketing, and support of the product in use.

All of these activities use written, numeric, or graphic data. This data is integrated into a working system by computers. The result is diverse operations integrated into a single, dynamic system.

CIM is an ultimate goal of many manufacturing enterprises. It is only beginning to be implemented into manufacturing companies today. Two main components of CIM, **computer-aided design (CAD)** and **computer-aided manufacturing (CAM)**, are commonly found. See Fig. 26-4.

CAD is a computer-based system used for creating, modifying, and communicating a plan or product design. Activities performed by CAD, as shown in Fig. 26-5, include:

- *Engineering design:* This is the preparation and documentation of various product design ideas and solutions.
- *Design analysis:* This is the evaluation of product designs using computer-simulated tests, such as for stress, heat transfer, and deflection.





* ARTIFICAL INTELLIGENCE (AI)
* COMPUTER-AIDED DESIGN (CAD) AND COMPUTER-AIDED MANUFACTURING (CAM)
* FLEXIBLE MANUFACTURING SYSTEM (FMS)
* PROCESS AUTOMATION
* JUST-IN-TIME (JIT)
* MANUFACTURING RESOURCE PLANNING (MRP II)
* MATERIALS REQUIREMENT PLANNING (MRP)
* BASIC MACHINE CONTROLS

Fig. 26-3. Computer use in manufacturing extends from relatively simple to highly complex tasks. (AT&T Co.)

- *Design presentation:* This is the preparation of engineering drawings that are used to communicate approved designs to manufacturing personnel.

Some references say CAD stands for computer-aided drafting. Some say that CAD is strictly a drafting tool. They refer to a system that also has design and analyzing capabilities as computer-aided drafting and design (CADD). More recent practice accepts CAD as standing for all drafting, design, and analyzing functions.

CAM is the use of computer technology in the management and control of manufacturing operations. CAM operation is concerned with one or both of the following:

- *Computer process control:* This is the process of using mechanical and electronic means (NC machines and robots, for example) to change the shape, size, or composition of materials.
- *Manufacturing support:* This is the processing of data including such things as machine status, part counts, and processing variables.

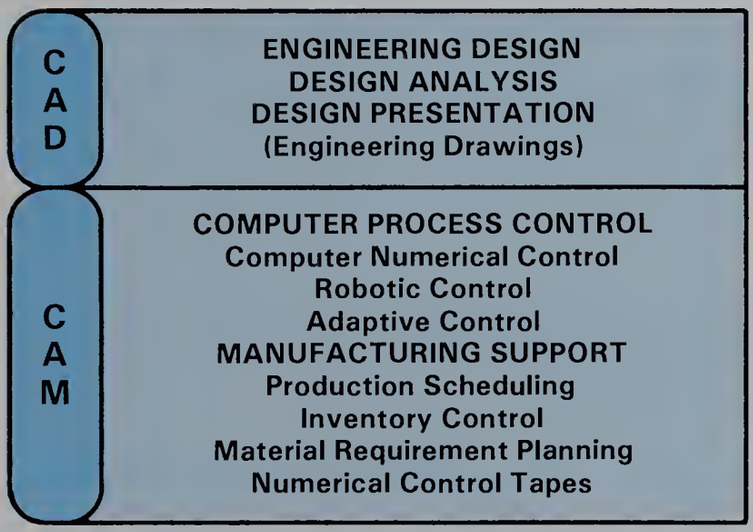
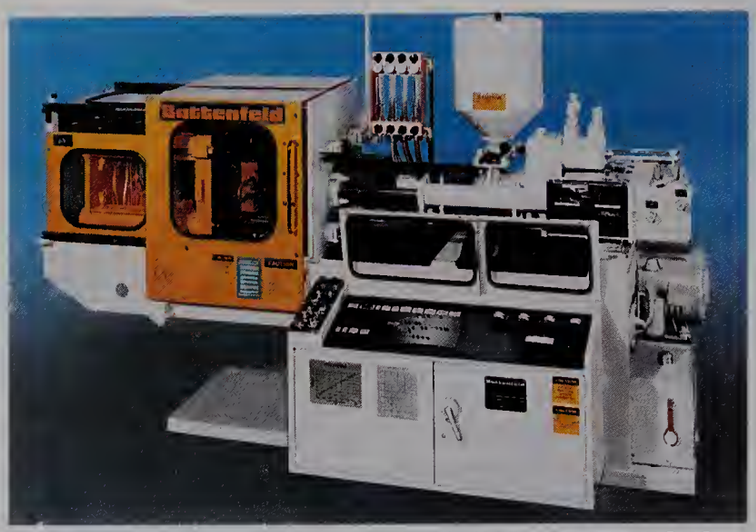


Fig. 26-4. CAD and CAM are important parts of computer-integrated manufacture.

CAM uses a computer to assist in monitoring and controlling either or both components of manufacturing operations, Fig. 26-6. Computers may be used to direct machines through a series of steps to process materials. Also, computers may gather and process data about the effectiveness of an operation.



CONTROLLING MANUFACTURING PROCESSES



PROVIDING MANUFACTURING SUPPORT

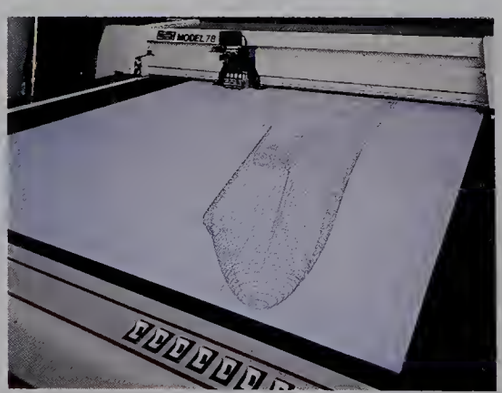
Fig. 26-6. Computer-aided manufacturing involves controlling operation and processing manufacturing data. (Battenfeld Inc., AT&T Co.)



ENGINEERING DESIGN



DESIGN ANALYSIS



DESIGN PRESENTATION

Fig. 26-5. Computer-aided design is used for engineering design, design analysis, and design presentation activities. (International Business Machines Corp., Ford Motor Co., Gerber-Scientific Instrument Co.)

Much more may be said about CAD and CAM operations. They will be the focus of the next two chapters of this book.

SUMMARY

Manufacturing companies are rapidly automating their operations in an effort to remain competitive in the world market. Computers are being used to make product design and manufacturing more efficient. Two major systems are widely used in industry today. They are CAD and CAM. Unified into a total system, they are a part of CIM.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

automation
computer-aided design (CAD)
computer-aided manufacture (CAM)
computer-integrated manufacture (CIM)

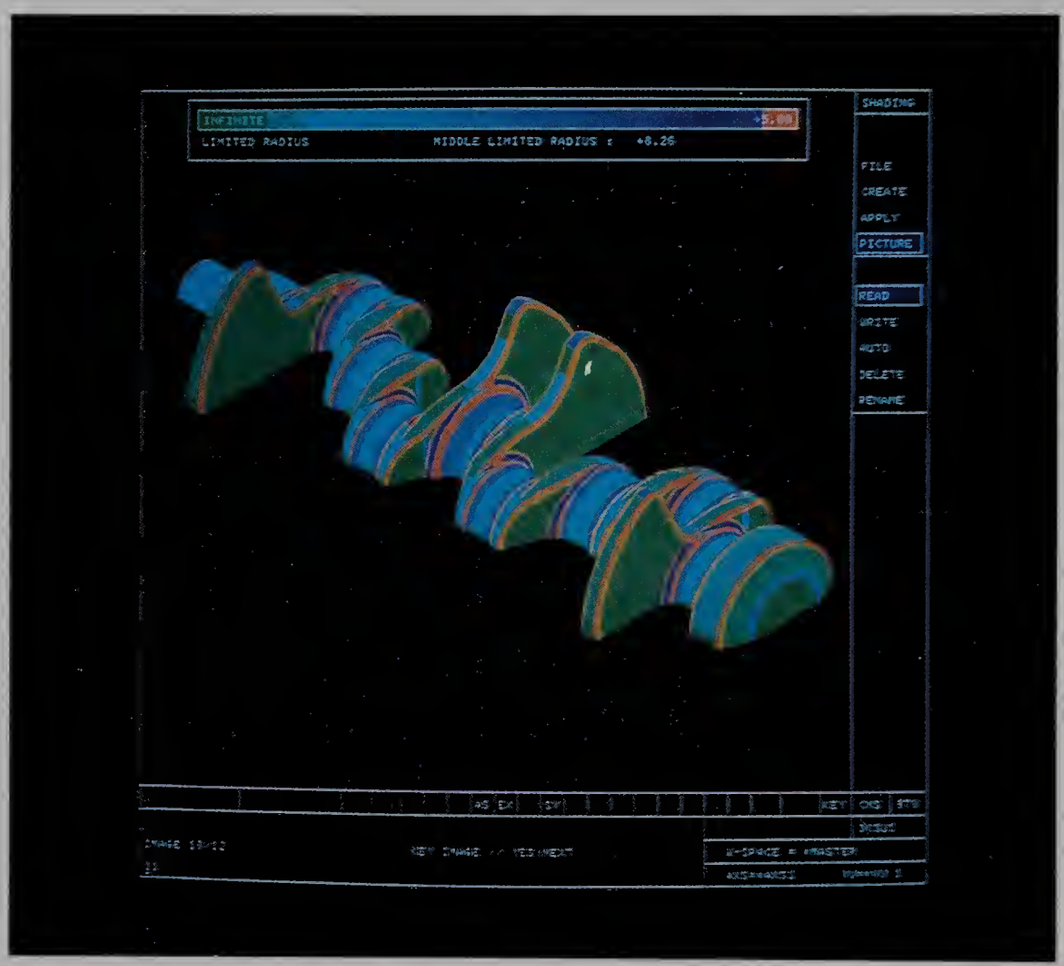
TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. True or False? Automation evolved as a result of a desire for more efficient ways to manufacture products.
2. Name three roots of automation.
3. What modern device revolutionized factory automation?
4. True or False? One reason manufacturers choose to automate is to increase product quality and consistency.
5. List three components of CIM.
6. Which of the following tasks do CAD systems help designers and engineers complete?
   a. Engineering design.
   b. Design analysis.
   c. Design presentation.
   d. All of the above.
7. What are the two major functions of a CAM system?

APPLYING YOUR KNOWLEDGE

1. Prepare a bulletin board that shows the major tasks of CAD and CAM systems.
2. Visit a local manufacturing company to observe CAD and/or CAM systems in operation. Write a brief report about what you observed.



CAD systems used in manufacturing have enhanced product design. (International Business Machines Corp.)

27

CHAPTER

COMPUTERS AND PRODUCT DESIGN

After studying this chapter, you will be able to:
- *List five types of computer hardware.*
- *Describe what software is.*
- *Name various applications of CAD.*
- *Explain the benefits of CAD.*
- *Describe the functions of engineering design and analysis.*

Traditionally, products have been designed by people working on drawing boards, Fig. 27-1. They use items like T-squares, triangles, and engineer's scales to develop a complete set of drawings for a product. In the realm of manufacturing, this set might include:
- Detailed engineering drawings showing the size and shape of the various parts.
- Assembly drawings showing how various parts fit together.
- Systems drawings showing electrical, mechanical, pneumatic, and hydraulic systems of the product.
- Tool and fixture drawings for special purpose devices used in manufacturing the product.

Today, traditional board drafting is becoming obsolete. Many companies are turning to CAD to improve the accuracy of their drawings, Fig. 27-2. Also, they are finding that CAD reduces the time it takes to prepare and/or modify drawings. In addition, they are using CAD because it allows the user to test and analyze a product design at the computer terminal.

COMPONENTS OF A CAD SYSTEM

A CAD system is made up of several components. Some of these are shown in Fig. 27-3. Components of



Fig. 27-1. Until recently, product drawings were prepared by drafters working at drawing tables.



Fig. 27-2. CAD systems allow drafters and engineers to prepare drawings more quickly and accurately.

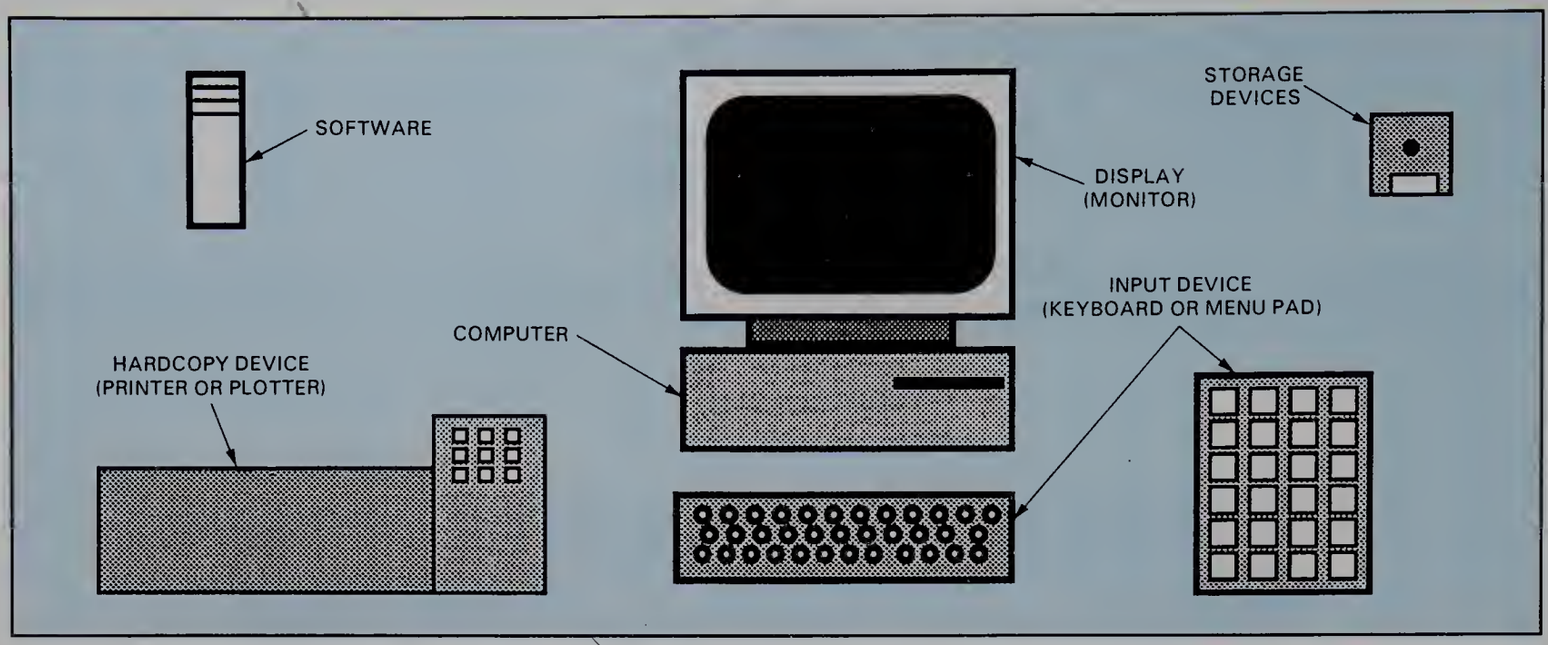


Fig. 27-3. A variety of parts makes up a CAD system. Note that most drawings in this book were produced on a CAD system.

CAD consist of computer hardware and computer software.

Hardware is the physical equipment of the computer system. It is comprised of:

- A **computer:** This is an electronic machine with internal parts that include a central processing unit, an input/output unit, and a memory. The **central processing unit (CPU)** controls and sequences the operations in the computer. The **memory** is used by the CPU for storing data. The **input/output unit** communicates with the peripheral devices (*external* input and output devices).
- A **video display terminal:** This is a peripheral device. It is sometimes called a VDT, a CRT, or a monitor. It is a video screen onto which the computer displays data [including graphics (drawings, graphs, charts, etc.)] for the operator's use.
- **Input devices:** These, too, are peripheral devices. They are used to enter data and directions into the computer. Input devices of a CAD system commonly include a keyboard, a digitizing tablet, and a tracking device.
- **Hard copy devices:** These are also peripheral devices. They may be plotters, film recorders, or printers. They are devices that are used to obtain hard copies (paper printouts) of the information processed by the computer. The output can be text, numbers, and/or graphics. Hard copy devices are output devices (as are video display terminals).
- **External storage devices:** These are disks or tapes used for storing data.

Software contains the set of instructions used by the computer. It directs general computer tasks like data processing and system operation. In a CAD system, it allows the computer to handle graphic data. It also allows drafting applications to be performed. Now let us take a look at applications of CAD.

APPLICATIONS OF CAD

CAD software allows for different applications of the system. Generally, these applications can be divided into three groups: mechanical, electrical/electronic, and architectural engineering and construction, Fig. 27-4.

Mechanical applications of CAD involve the design and layout of parts and products. They are represented by 2- and 2 1/2-dimensional drawings and 3-dimensional models. A *2-dimensional drawing* is

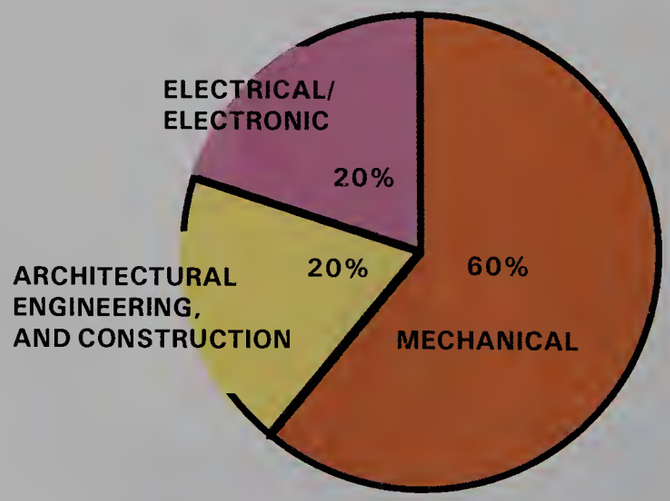


Fig. 27-4. This chart shows the percentage of the total for each of the three major applications of CAD.

used to define the shape of an object using one or more profiles. A *2 1/2-dimensional drawing* is used when the side of an object does not need to be profiled. A *3-dimensional model* is used to give a pictorial view of an object. A model aids evaluation of the size, shape, and performance of a product. Models are essential when the part is to be manufactured by multiaxis, computer-controlled machines.

Electrical/electronic applications of CAD involve the design and layout of components and wiring in electrical and electronic circuits. The circuit designer is concerned with the location of components and the interconnections between them.

Architectural engineering and construction applications of CAD involve the design and layout of buildings and their related systems and/or surroundings. In this application, architectural, mechanical, and electrical drawings are produced. These are in the form of plans, elevations, and section views. Plans show overall layout; elevations show side views; section views show cross sections.

CAD serves other uses as well. It is used in applications of civil drafting of land terrain, road systems, and utilities. In the applications mentioned, it is often used, not only for design and layout, but for such things as preparing bills of materials and generating production schedules and cost estimates.

BENEFITS AND FUNCTIONS OF CAD

CAD is used for a variety of beneficial reasons. It is quicker than traditional drafting. Standard symbols on file can be used, and repetitive objects can be quickly reproduced. It produces better quality drawings. It facilitates drawing modification. It allows drawing manipulation and product analysis. For example, a three-dimensional model can be changed into a three-view, orthographic drawing in seconds. This task could take hours or days using traditional drafting methods.

Three basic functions of CAD were briefly introduced in Chapter 26. These were:

- Engineering design.
- Design analysis.
- Design presentation.

These functions, Fig. 27-5, are important and interrelated. All contribute to an effective and efficient product design.

ENGINEERING DESIGN

Engineering design involves developing drawings from product sketches. Traditionally, products were designed with little attention to their manufacture. Appearance was considered the primary challenge for designers. However, this has changed because of today's competitive environment. A new approach is being used. This approach is called *design for manufacture (DFM)*, *design for assembly (DFA)*, or *design for manufacture and assembly (DFMA)*.

This new approach strives to design an appealing, functional product that can be easily manufactured and assembled. The results are dramatic. One company redesigned the sight used for the guns it made. It reduced the part manufacture time by 71 percent, the number of parts by 75 percent, and the sight

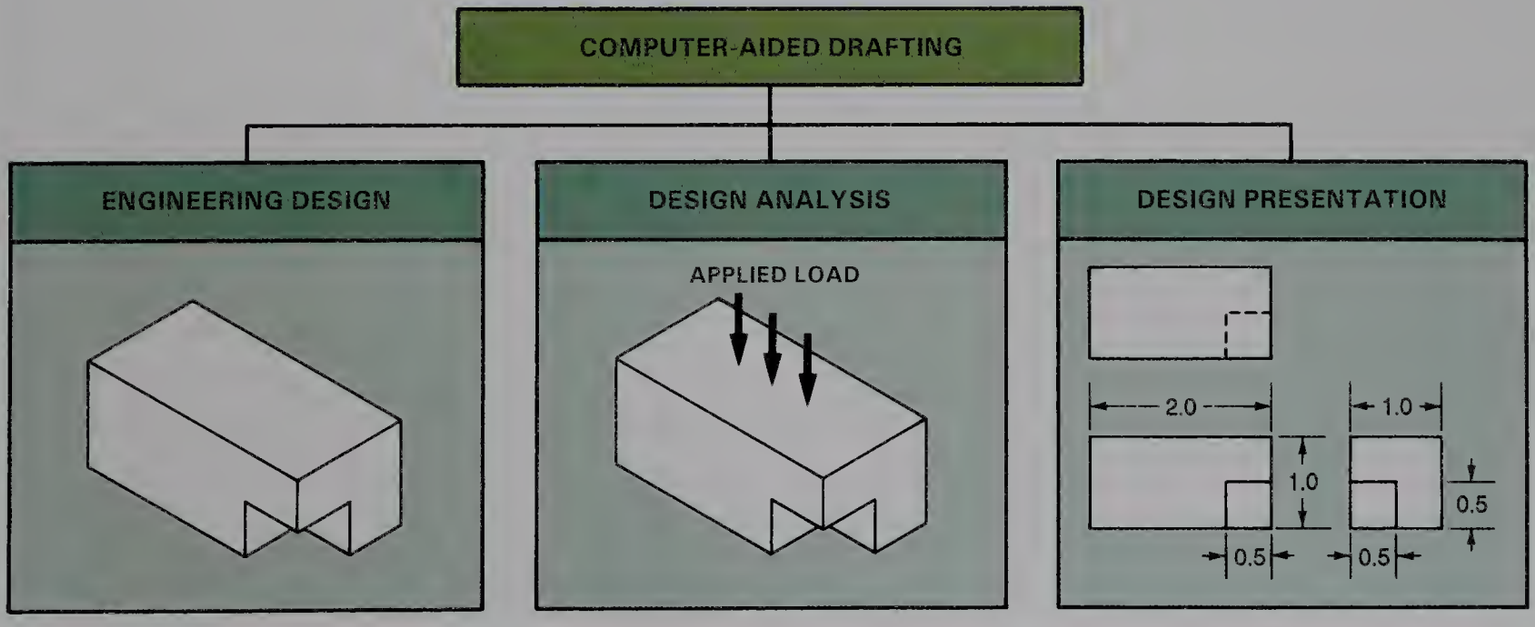


Fig. 27-5. The functions of CAD are pictured. A sketch becomes a design; the design is analyzed (in this case, for reaction to external forces); a multiview is presented showing shape and dimensions of the design.

assembly time by 85 percent. Another company used DFA to reduce the assembly time of a printer it manufactured from 30 minutes to 3 minutes. Still another company redesigned its cash register so that it could be assembled in less than 2 minutes. Such accomplishments translate to cheaper, more competitive products for the customer and more profit for the company.

DFM includes carefully defining the appearance and the shape of a product. All parts are designed to be as simple as possible. Unnecessary parts are eliminated, and, wherever possible, small parts are combined with larger parts.

The design effort refines the styling of a product. Product shapes and lines are simplified. Curves that are hard to manufacture are removed wherever possible. Then, drawings for each part and a finished assembly are produced.

CAD makes these tasks much simpler. Generally, designers working with CAD start by producing a wireframe model of the object being designed. A **wireframe model** is a series of lines, circles, and arcs that together form an outline of an object. This type of model, as seen in Fig. 27-6, is a series of overlapping lines.

The wireframe model is fairly easy to make and does not require a great deal of computer skill. However, it is not the best way to see an object. The model fails to adequately show the relationship between surfaces and edges. The lines of the wireframe often produce a confusing outline.

A CAD system can quickly change the wireframe model into a surface or a solid model. A **surface model** is a representation whereby an object is defined only by its surface. It is created by putting a "cover" around a wireframe model. An empty can could be properly defined by a surface model. Such a model could represent a solid object such as a brick, but to the computer, it would be hollow. A surface model better shows how an object will look when manufacture of it is complete.

A **solid model**, Fig. 27-6, is a true representation of an object whereby its surface *and* its interior substance is defined. A computer treats a solid model as though it were a truly solid object. Solid models are helpful for product analysis. They also enable cross sections of a product to be viewed.

A lifelike view can be produced by having the CAD system change the solid model into a **perspective model**, Fig. 27-6. This type is like a surface model shown in perspective as the human eye would see it.

The surface and perspective models are very important in making styling decisions. They allow the

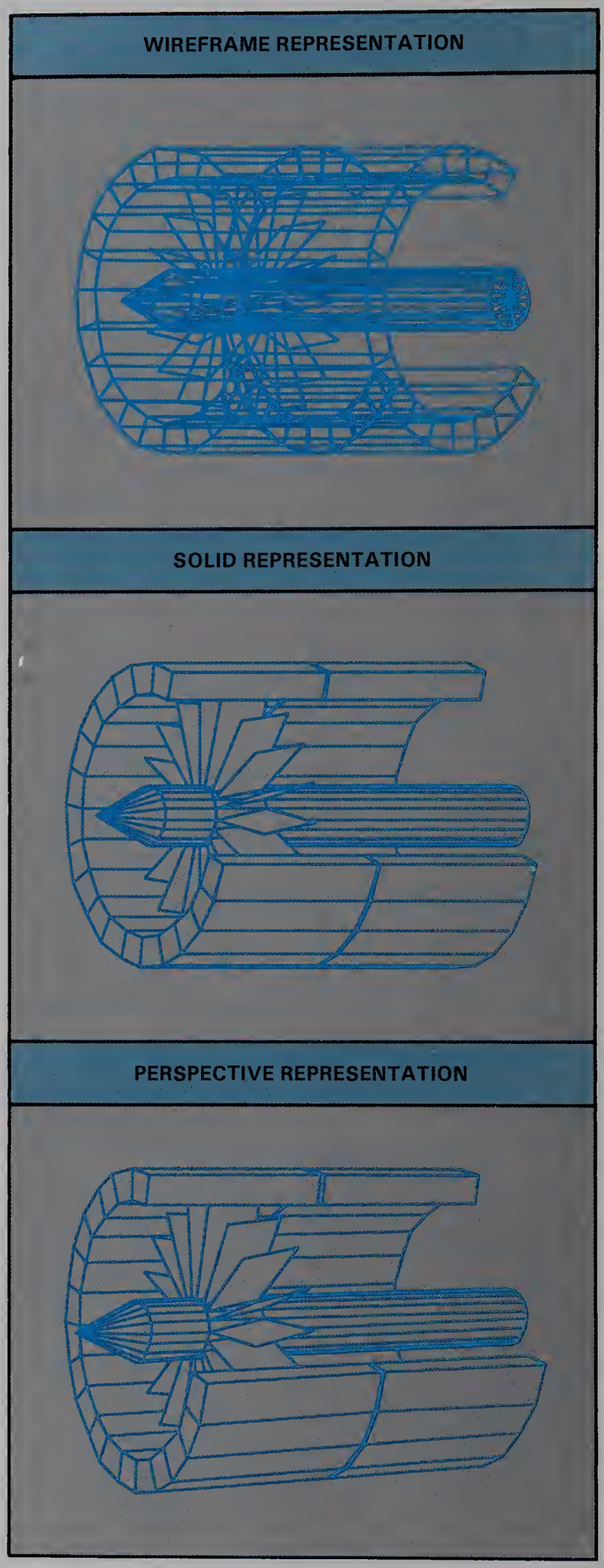


Fig. 27-6. These different models showing a turbine were produced with a CAD system.

designer to "see" the object before it is built. In fact, most CAD systems are able to rotate an object through a series of views, Fig. 27-7. This feature lets designers view the product at any angle. It allows them to decide if the styling is pleasing from all vantage points.

Finally, as mentioned before, a CAD system can take a model of an object and show it in three views. These are the traditional views used in orthographic projection–top, front, and right side. See Fig. 27-8.

DESIGN ANALYSIS

Almost every new product must be subjected to design analysis, Fig. 27-9. This review determines if the product will function as intended. Typically, the analysis may evaluate the performance of the product under normal and extreme operating conditions. This would involve evaluating the physical properties of the product. Its ability to withstand stress from stationary or moving forces, for example, might be analyzed. Many CAD systems allow the user to simulate the conditions under which they may evaluate the product design. They can place loads on the design and simulate operating demands. Also, advanced CAD systems can simulate manufacturing operations. From this, they can develop numerical control codes to control machines.

DESIGN PRESENTATION

Engineering drawings document a designer's product ideas. The drawings become a vital tool for many company activities. Their use extends far beyond the realm of research and development. Tooling designers, industrial and manufacturing engineers, production planners, package designers, machine setup people and operators, and production supervisors are but a sample of the people that need accurate drawings.

Many projections suggest that drawings on paper will become obsolete. It is expected that data will move from the CAD system directly to manufacturing machines and inspection stations. The product specifications will be stored in computer memories. The information will be readily available to anyone in the company who has access to a computer terminal. The costly activities of printing, distributing,

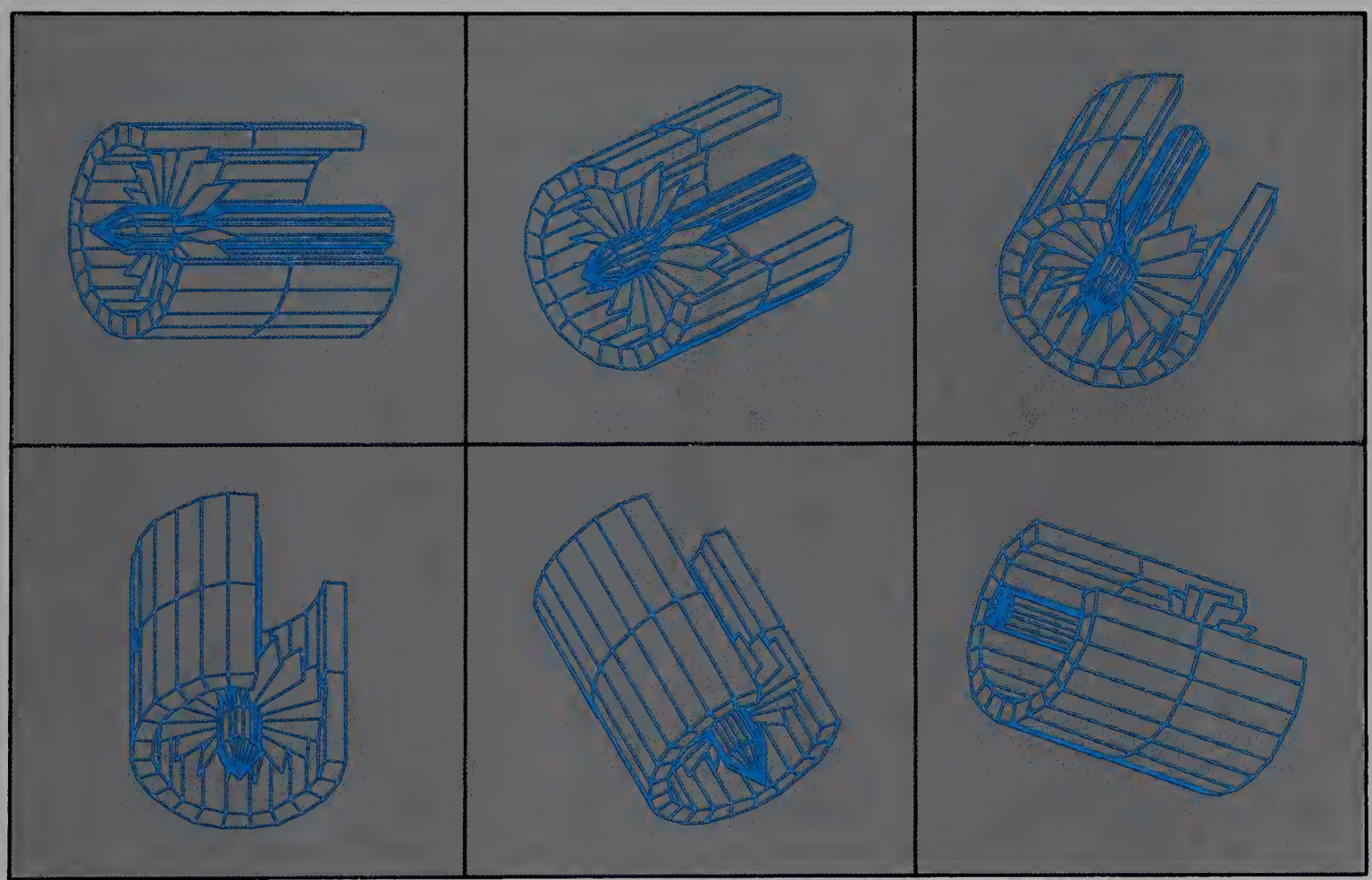


Fig. 27-7. These drawings show a turbine rotated through a series of views by a CAD system. (Super 3D, Silicon Beach Software)

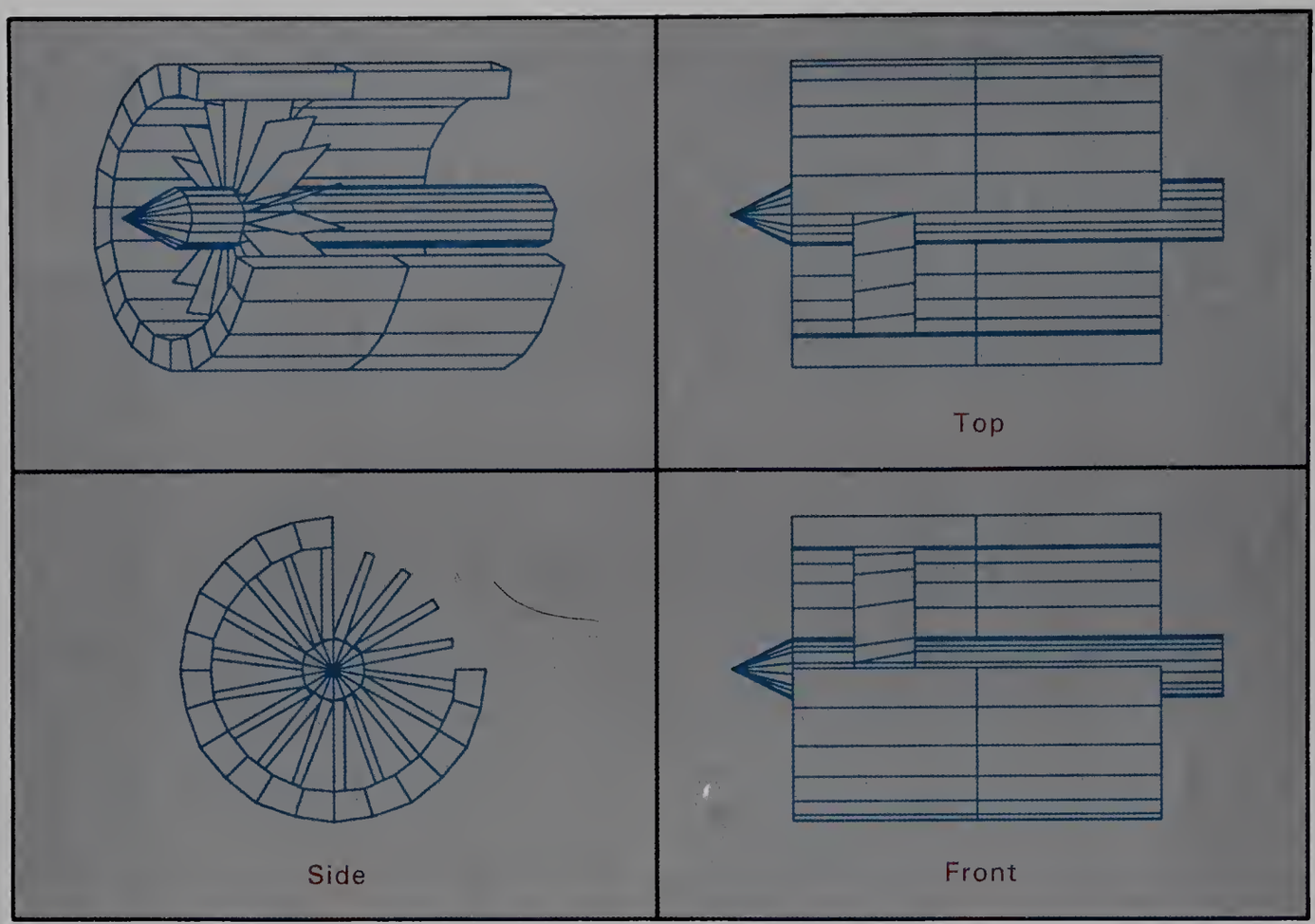


Fig. 27-8. These drawings show a multiview of the turbine shown in the upper left corner. (Super 3D, Silicon Beach Software)

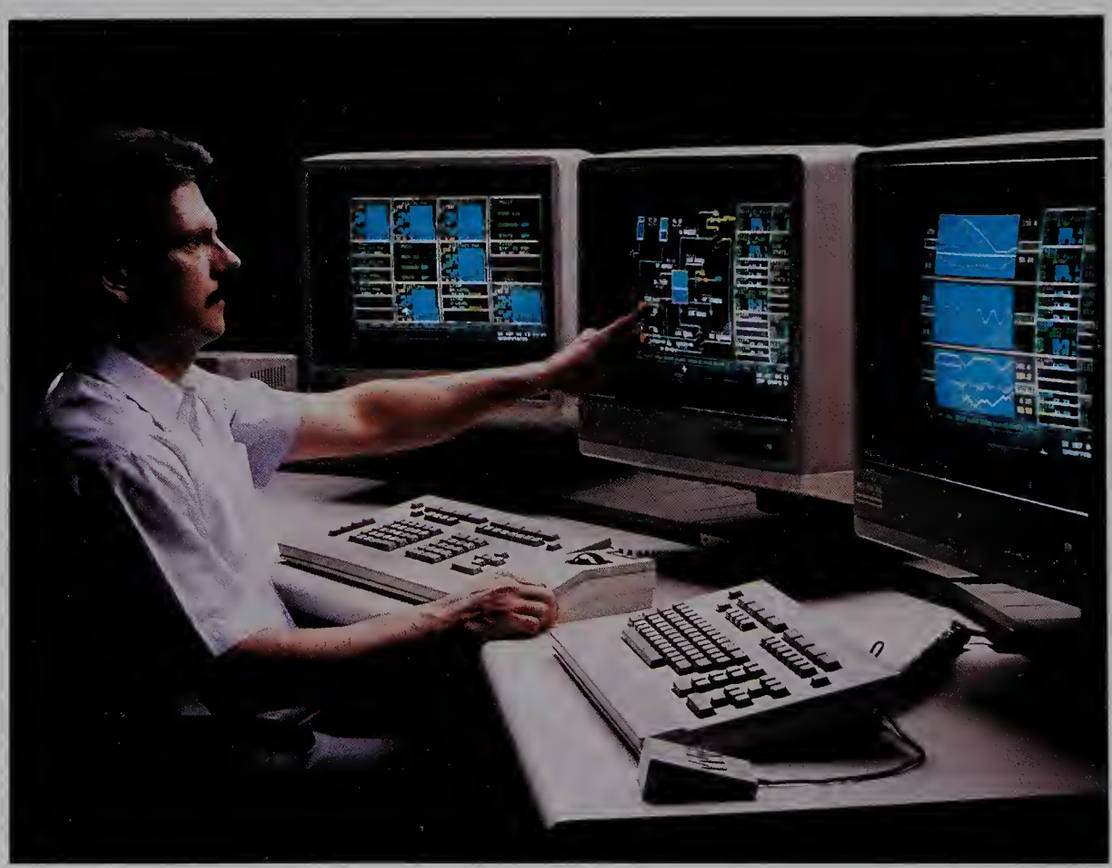


Fig. 27-9. This engineer is using a multiple-screen CAD system to conduct a design analysis of a product. (AMP Incorporated)

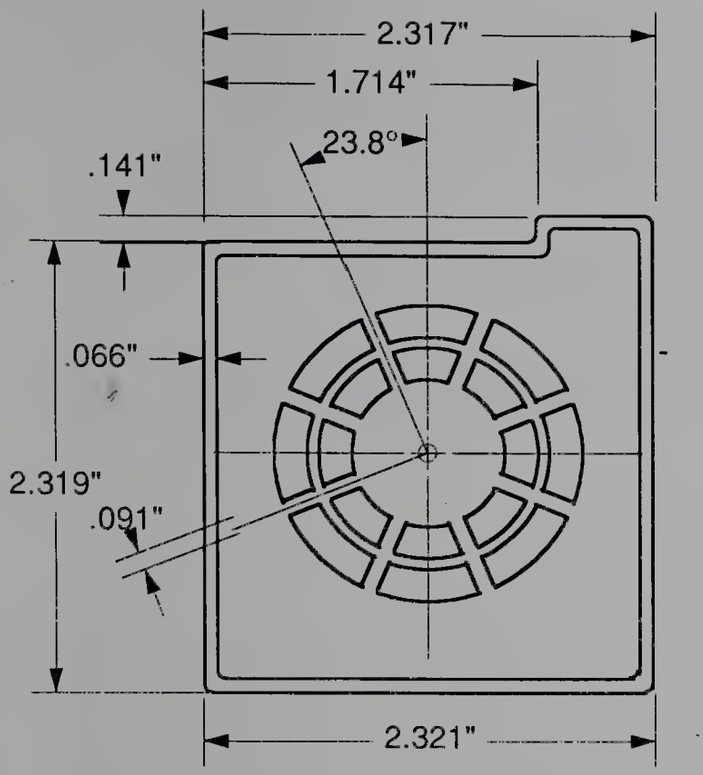


Fig. 27-10. Pictured is a simple drawing produced on a CAD system.

and storing drawings will be eliminated. Also, the need to retrieve and destroy out-of-date drawings will be removed.

However, such a time is well off in the future for all but the most advanced companies. Most manufacturing enterprises still need typical engineering drawings, Fig. 27-10. These are quickly produced by CAD systems. The information in the computer's memory is used by plotters, film recorders, and printers. They produce up-to-date, accurate drawings and pictures.

SUMMARY

CAD is an increasingly important system to most contemporary manufacturing enterprises. It allows a company to speed up its engineering design, design analysis, and design presentation activities. The systems promise to become part of a larger, more effective, computer-integrated manufacturing system.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

central processing unit (CPU)
computer
external storage devices
hard copy devices
hardware
input devices
input/output unit
memory
perspective model
software
solid model
surface model
video display terminal
wireframe model

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. Study Fig. 27-2. Which components of a CAD system do you see in the photo?
2. List and describe the three major applications of CAD in industry.
3. Describe the concept of DFM.
4. As listed in the chapter, the three functions served by a CAD system are _____, _____, and _____.
5. Which of the following is a type of model used by CAD for product design?
   a. Wireframe.
   b. Solid.
   c. Perspective.
   d. All of the above.
6. True or False? CAD is limited in that it is unable to simulate operating conditions for product evaluation.

APPLYING YOUR KNOWLEDGE

1. Use a simple CAD or graphic software package to make a drawing of the part shown in Fig. 27-A.

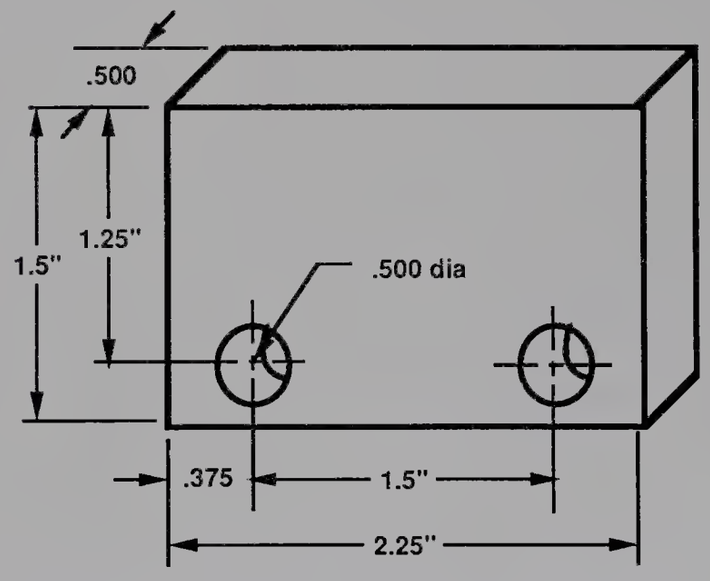


Fig. 27-A. This part is easily drawn on a CAD system.

2. Select and analyze a product that you use often. On a form like that in Fig. 27-B, list ways you could improve its DFM and DFA.
3. Visit a company to see how they use CAD in their operations.
   a. Prior to your visit, research CAD operation in the school library or resource center.
   b. Prior to your visit, prepare a list of questions to ask about the company's CAD operation.
   c. After your visit, list ways you could use a CAD system in this class.

PRODUCT: _____

SUGGESTED IMPROVEMENTS FOR:	
MANUFACTURE	**ASSEMBLY**
1. 2. 3. 4. 5.	1. 2. 3. 4. 5.

Fig. 27-B. A suggested form is shown.

28

CHAPTER

COMPUTERS AND MANUFACTURING

After studying this chapter, you will be able to:

- *Name and describe two major elements of a CAM system.*
- *Name and describe three kinds of automated machines and systems.*
- *Give examples of classes of NC machines.*
- *Explain the importance of NC programming coordinates.*
- *List and describe four systems that have advanced NC.*
- *Cite applications where robots are useful.*
- *Explain what end effectors are.*
- *Name and describe four management information systems.*

Recent history has seen companies dramatically increase their use of computers to help improve manufacturing efficiencies. You have been studying manufacturing throughout this book. You have probably become aware that manufacturing is not a simple process. It involves two major and often complex activities. These are:

- *Material processing:* This is the physical act of changing the form of material to make it more valuable to customers. This involves making industrial materials out of natural materials and finished products out of industrial materials.
- *Management:* This is the action taken to plan, organize, actuate, and control an organization's activities. Management is apparent in research and development, production, marketing, employee relations, and financial affairs.

Computers are used in all of these areas to help promote efficiency. Specifically, computer-aided manufacture shows great promise in helping to improve a company's ability to make products that are competitive in a world market. It addresses areas of manufacturing that move a concept from engineering drawings to finished product, as shown in Fig. 28-1. CAM may be integrated with computer-aided design to produce a truly computer-supported manufacturing system. This integration, as discussed in Chapter 26, is computer-integrated manufacture.

There are a number of ways to view the elements of CAM. For this discussion, we will divide it into two major areas:

- Machine and process control.
- Management information systems.

MACHINE AND PROCESS CONTROL

The ability to work with metals was developed nearly 6000 years ago. The processes used were, at first, simple and crude. Later, machines were invented to help the artisan produce more and better products. However, it was not until after the mid 1700s that automation really began to be applied to product manufacturing. This movement was hastened by the invention of some basic machines including the turret lathe and the automatic screw machine.

The most significant breakthrough in machine automation came with the development of numerical control. This event took place in the early 1950s. It made way for more complex, automated machines and process control systems. From it evolved computer-directed numerical control, industrial robots, and flexible manufacturing systems. See Fig. 28-2.

NUMERICAL CONTROL

Numerical control (NC) is the programmable control of manufacturing machines as directed by a code of numbers, letters, and other symbols. This code

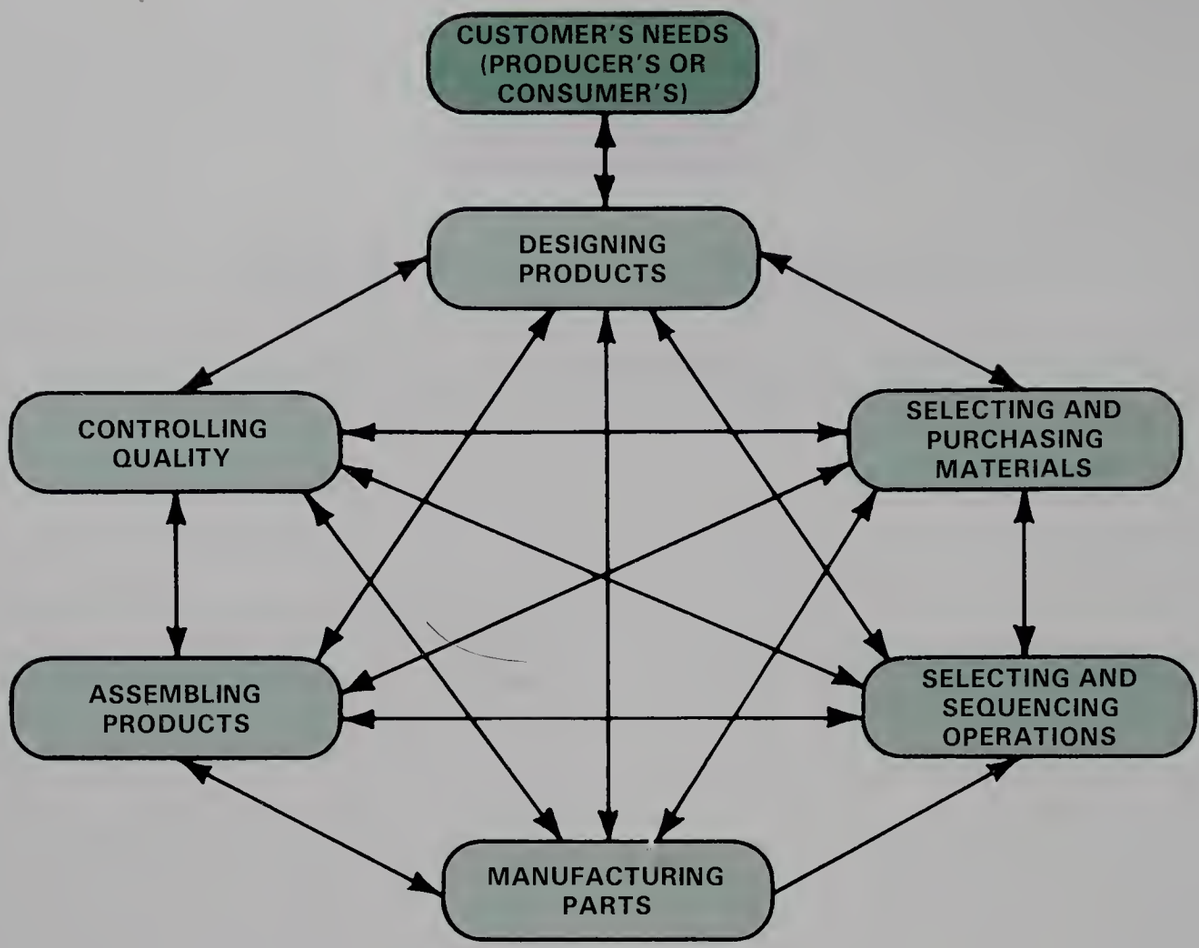


Fig. 28-1. Computers can be integrated into all aspects of manufacturing.

makes up the program of instructions. It tells the machine controls what to do. The controls then activate the machine drive mechanisms (motors, gear trains, etc.) in order to produce a specific part. Whenever the part changes, the numerical code must also change.

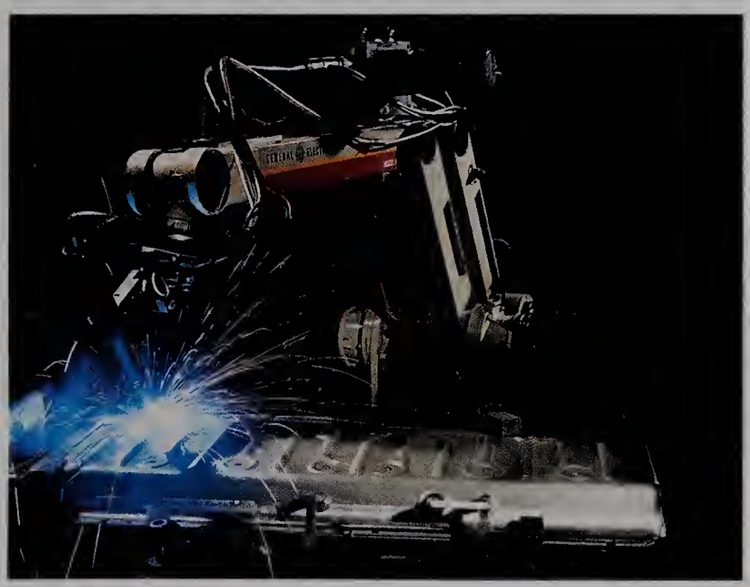


Fig. 28-2. Industrial robots evolved from NC machines. This robot is spot-welding a catalytic convertor. (Arvin Industries)

NC machines have three basic parts, Fig. 28-3. These are:

- A *machine tool:* This is a power-driven machine used for the shaping, cutting, turning, boring, drilling, grinding, or polishing of solids, especially metals.
- A *control unit:* This is a unit that includes a tape reader and control devices. It sends signals to and receives signals from the machine tool. It affects machine tool operation.
- A *program:* This is a detailed set of instructions. The program directs machine tool operation via the control unit.

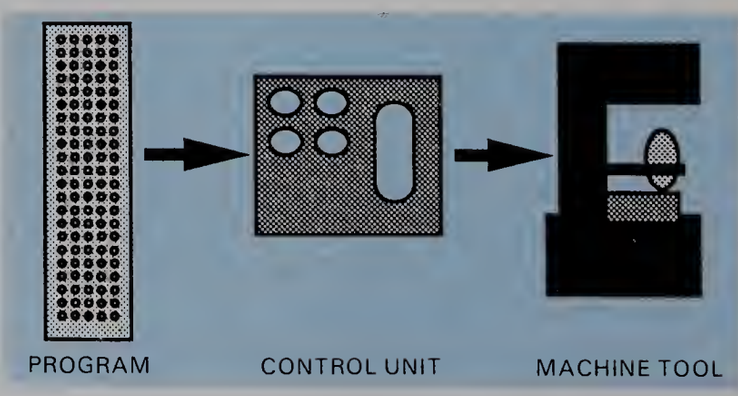


Fig. 28-3. NC machines have three basic parts.

Classes of NC machines

NC has been applied to a number of machines. Commonly included are metal- and wood-cutting machines, tube- and rod-bending machines, assembly machines, bending and shearing presses, and welding and flame-cutting apparatus. NC machines may be separated into three classes based on their mode of tool (cutting element) positioning, Fig. 28-4. These are:

- Point-to-point machines.
- Straight cut machines.
- Contouring machines.

Point-to-point (PTP) machines. PTP machines position the tool above a point on a workpiece while it is clear of it. The machine then performs a specific operation. After completion, the tool is moved to the next point and the operation is repeated.

An NC drill press is a good example of a PTP machine. In operation, the workpiece is first clamped on the machine table. The table is then moved until the workpiece is positioned under the drill bit at the location for the first hole. The table stops, and the drill is fed downward producing the hole. The drill is then retracted, and the workpiece is positioned for the next succeeding holes.

Straight cut machines. Straight cut machines make straight-line cuts through a workpiece. Only cuts parallel to a major machine axis (discussion of which follows) are possible. Straight cut machines will produce parts with rectangular configurations. They cannot produce angular cuts. Straight cut machines can perform point-to-point operations.

Contouring machines. Contouring machines are the most complex and expensive NC machine. They can move on any or all machine axes at the same time. This allows the tool to follow curved paths. Contouring machines can also be used to do point-to-point and straight-line work.

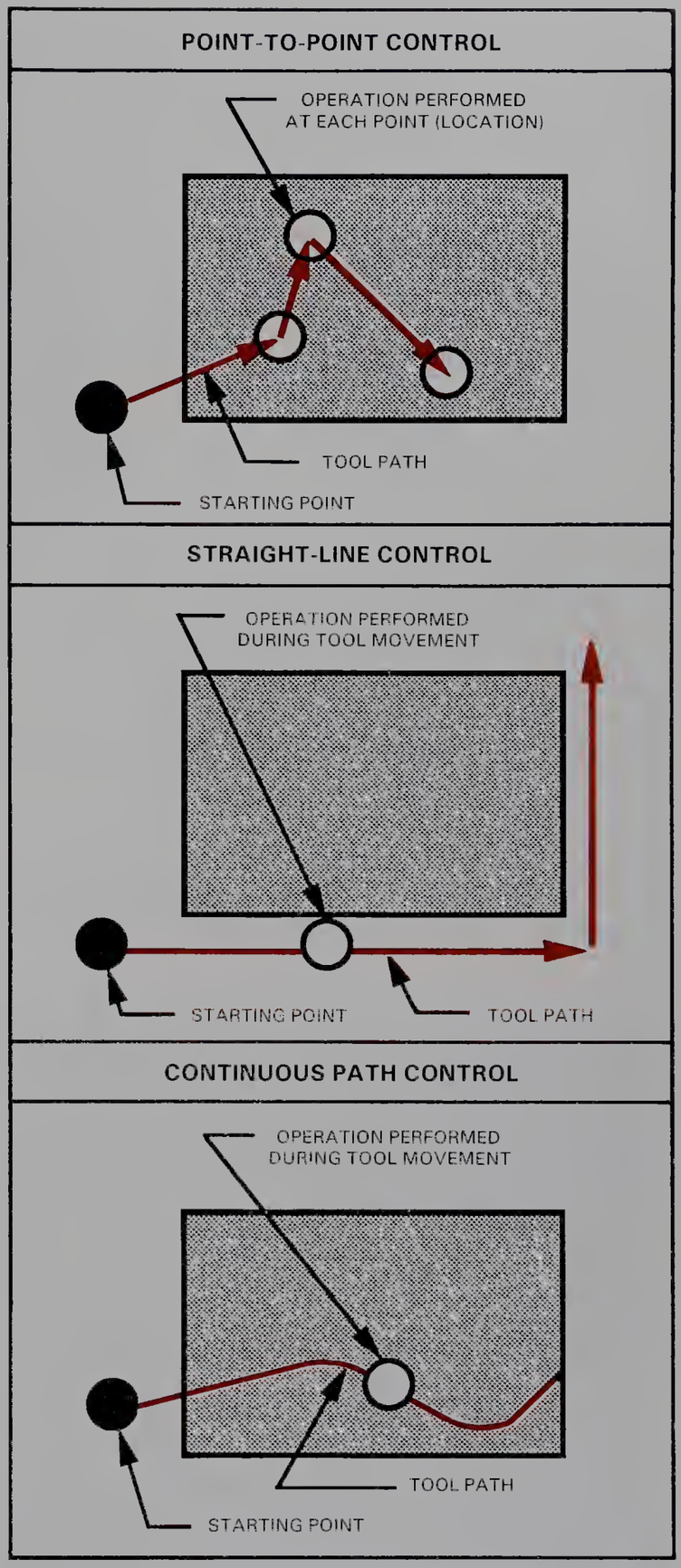


Fig. 28-4. There are three classes of NC machine.

NC programming coordinates

Location, size, and shape data for all NC machines are developed around a coordinate system. This system specifies machine tool motions using X, Y, and Z rectangular coordinates, Fig. 28-5. The X axis is usually horizontal. It runs parallel to the movement direction of what is called the machine *table*. The Z axis runs parallel to the axis of what is called the machine *spindle*. The Y axis is at right angles to both the X and Z axes. It runs parallel to the movement direction of what is called the *traverse cross feed* or *saddle*.

Coordinates make it possible to define the shape of a part. They are assigned to a part design relative to a chosen point of reference. This point, called the origin, is where all axes intersect. It is the zero point. Distances are measured from the origin and are assigned X, Y, and Z coordinate values. One direction from the origin is measured in positive units and the other in negative units. For example, a point located

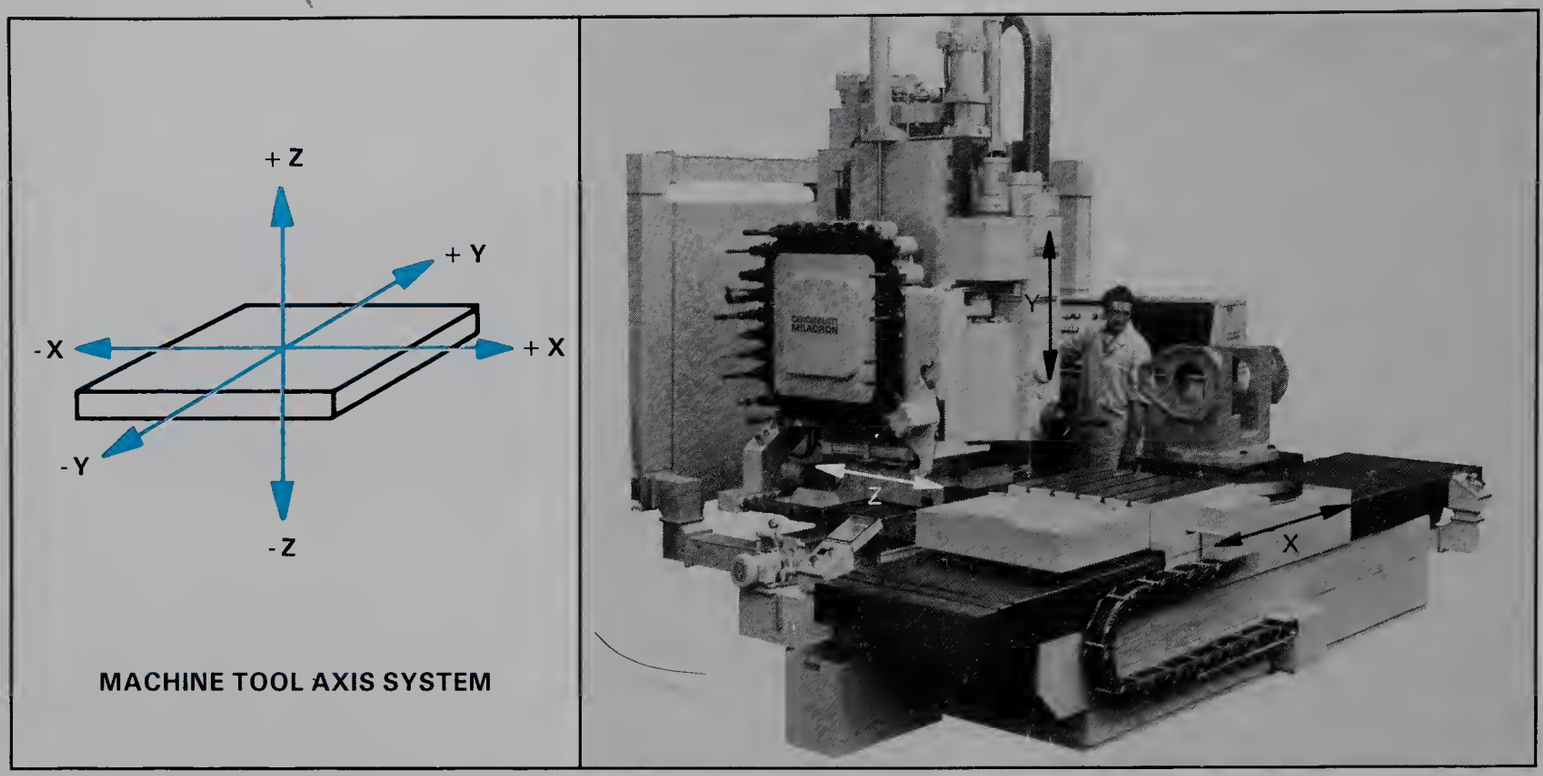


Fig. 28-5. A standard three-axis coordinate system is shown (left). The X and Y axes are said to lie in the same plane with the Z axis passing through it. The machine pictured (right) has three primary machine axes. The Z axis is reserved for the spindle regardless of whether it is horizontal or vertical. (Cincinnati Milacron)

at position (1,2,-4) is one positive unit on the X axis, two positive units on the Y, and four negative units on the Z axis. This point can be communicated to the machine controls in numerical code.

NC programming

NC programs are commonly found on punched tape. The holes in the tape enable the input of data to the machine control unit. The data is relayed through pulses of electricity caused by the holes. The control unit commands different tasks with different pulses. Data may be a number value or an instruction. Number values may be coordinate locations or speed and feed values. Instructions include axis commands, speed, feed, tool change, coolant start/stop, and machine start/stop.

The tape is developed by a process planner and a machine programmer. Drawings are analyzed for proper machine X, Y, and Z coordinates. Materials for processing are considered. The proper machine and cutting tools are selected; speeds and feeds for each operation are figured. Coolant requirements are determined. Based on these variables, a program is then written. Finally, the tapes are punched and checked.

Advances in NC

NC revolutionized material processing and assembly. Since its development, it has not remained static. Additional systems have advanced NC. These are:

- Direct numerical control.
- Computer numerical control.
- Machining centers.
- Adaptive control.

Direct numerical control (DNC). DNC was the first extension of basic NC technology. This type of system was developed in the 1960s. It uses a master computer to control a number of machine tools, Fig. 28-6. The tape reader of NC is supplemented with a computer and its memory. The DNC computer provides operating instruction for each machine tool in its system. It communicates specific directions to each one as needed. DNC systems have a computer, which has a memory for storing the NC program, a communication link (wiring), and a number of machine tools.

Computer numerical control (CNC). The development of a fairly fast and inexpensive minicomputer has allowed a new type of computer-directed NC system to be introduced. This system, called CNC, looks very much like a traditional NC machine. The main difference, as with DNC, is that a computer supplements the NC tape reader, Fig. 28-7. Unlike DNC, each machine tool is controlled by its own computer. This feature allows for more flexibility and, in most cases, is cheaper to install.

Machining centers. These take NC one step further. They are very complex, manufacturing

machines, Fig. 28-8. These machines are computer controlled. They have five basic features. First, they can perform several different types of operations. They may drill, bore, ream, tap, mill, and face a part. Second, they can change tools automatically. Third, they can position a workpiece so that operations can be performed on several sides. Fourth, they have two tables so that a part can be machined on one while a new part is positioned on the other. Fifth, they are numerically controlled and run without a machine operator.

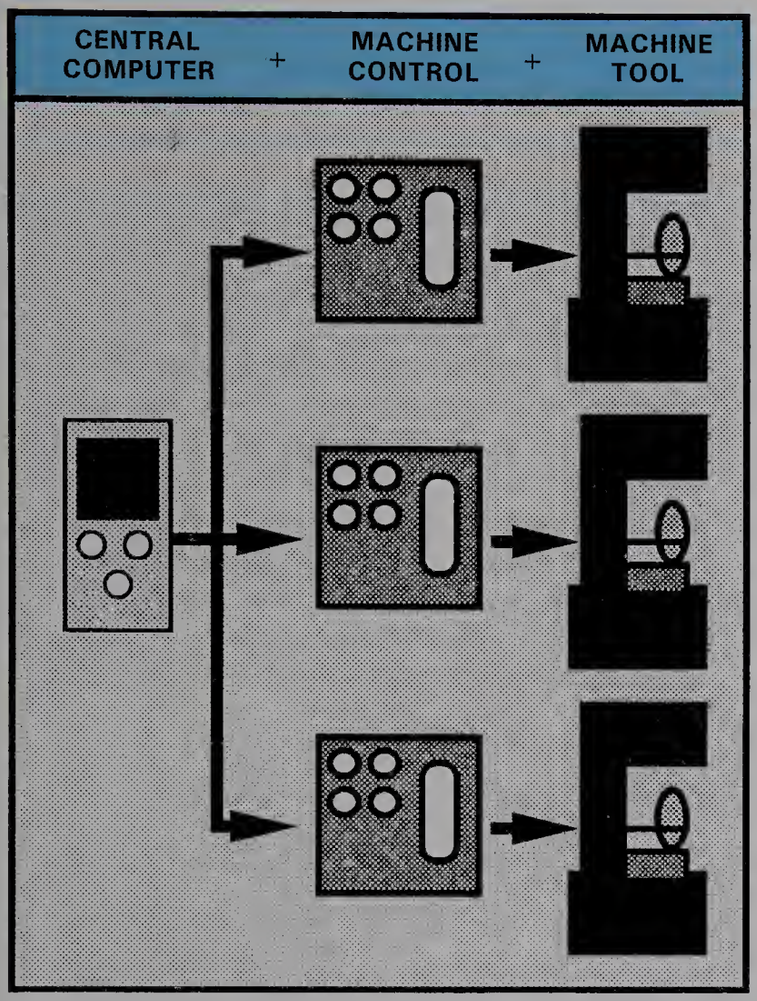


Fig. 28-6. A schematic of a DNC system is shown here.



Fig. 28-7. The control unit for a CNC machine is shown. (General Electric Co.)

Adaptive control. NC machines removed the operator from positioning work and from operating machines. The NC program took the operator's place. However, these programs have limitations. Machine speed and feed settings are written into the NC programs. These settings cannot be adjusted for specific operating conditions and problems. For example, as a cutting tool starts to become dull, it cuts slower. The tool feed needs to be reduced, but the program cannot sense this need. In another case, a drill bit tries to wander as it starts to cut a hole. It also grabs as it finishes the cut. At the start and finish, the speed and feed of the bit should be reduced to compensate for these problems and to lessen drill breakage.

To address this type of problem, adaptive control was developed. Adaptive control automatically adjusts a machine tool so that it adapts to operating conditions. It measures machine variables and then adjusts feed and/or speed rates. Machine variables measured may be spindle torque, horsepower, vibration, or cutting temperature. Adaptive control



Fig. 28-8. This machining center is processing a large tractor part. Notice the tool cassette that holds tools for various programmed operations. (Caterpillar Tractor Co.)

increases tool life, machine productivity, and product quality.

INDUSTRIAL ROBOTS

Automation in manufacturing often requires automatic material handling. Parts must move from one machine to another. There are a number of automatic material handling systems. One of these systems is the computer-directed *automatic storage and retrieval system (AS/RS)*. This system will automatically locate and retrieve parts and materials stored in special warehouse racks. AS/RS will also store parts and materials. Another material handling system uses *automatic guided vehicles (AGVs)* as shown in Fig. 28-9. These driverless vehicles will move parts to and from machines. A computer commands the AGV to move to a specific location. It then follows guideways in the floor to that location.

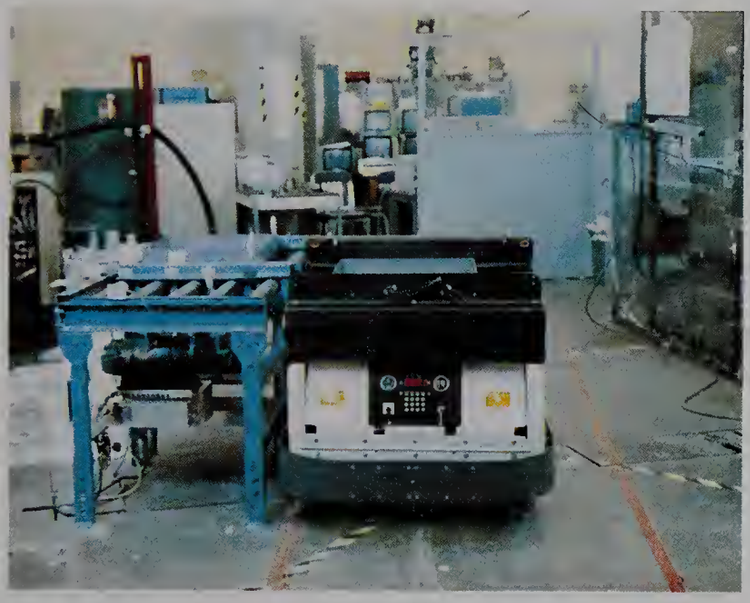


Fig. 28-9. Pictured is an AGV in a manufacturing setting.

One very important material handling device is the **industrial robot.** This device is defined as a programmable, *multi*functional manipulator designed to move material, parts, or tools for the performance of a *variety* of tasks. A key distinction of a true robot is that it may be reprogrammed.

Applications of robots

Robots are used for a number of reasons. They can perform routine tasks, for example, loading and unloading parts into machines. They can perform repetitive tasks, for example, painting and welding, Fig. 28-10. Robots can also perform operations that would be unsafe for humans. As an example, they are used for loading and unloading materials into punch presses. They are ideal for handling hot, corrosive, or toxic materials, which are also considered unsafe for humans.

Fixed and variable sequence robots

Robots perform their tasks through the specific direction of a control unit. This unit may be designed for fixed or variable sequences. A **fixed sequence**

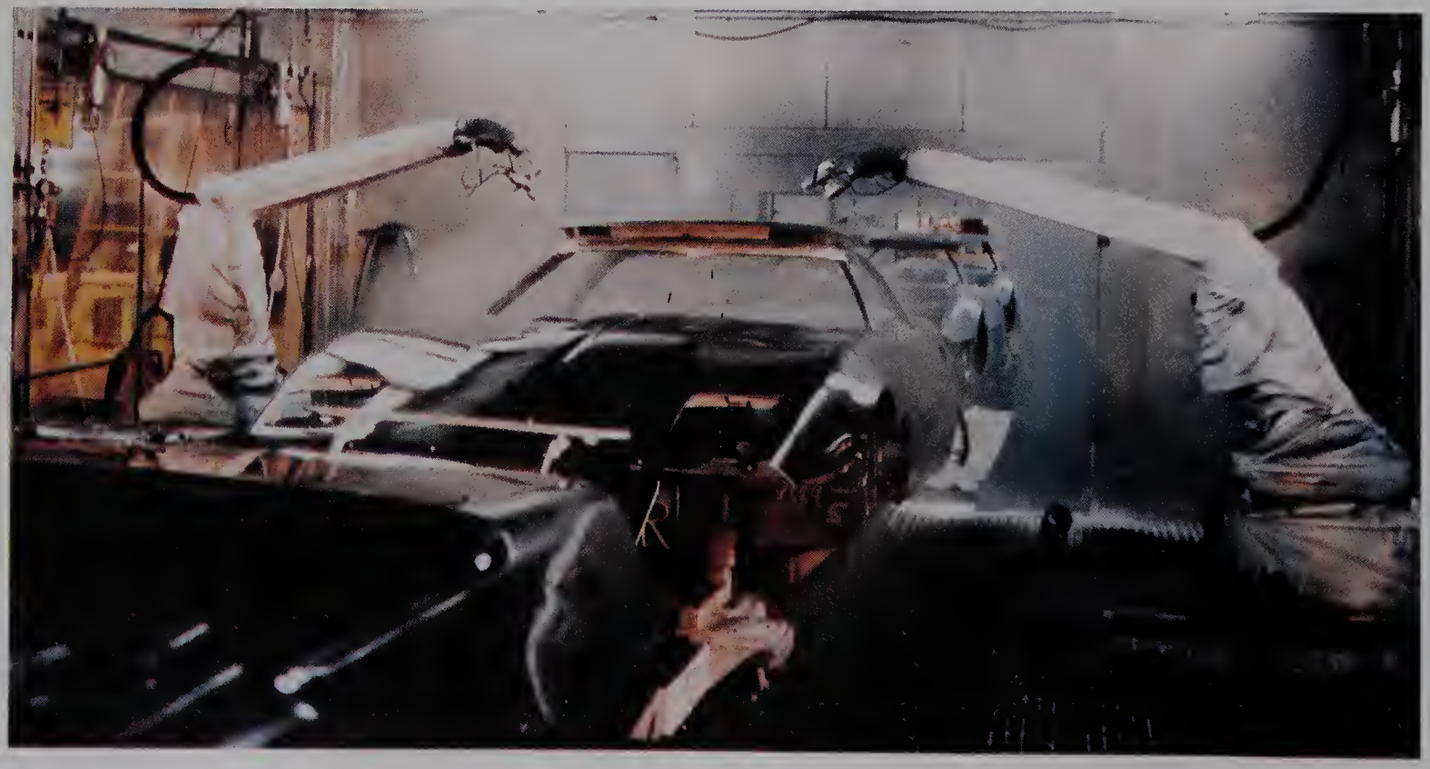


Fig. 28-10. These industrial robots are used for spray painting an automobile body. (DeVilbiss Co.)

robot is a simple robot. It has limited versatility. It often employs a *pick-and-place* action such as that used to load or unload a machine. The robot moves to a position. It picks up a workpiece. It moves to a second position. It then places the workpiece in a die or other machine part. Later, the robot picks up the machined part and places it in a tray or on a conveyor. This sequence of picking up a part in one location and placing it in another gives the robotic action its name, i.e., pick-and-place.

Variable sequence robots are more complex and versatile. They are programmed to complete a specific task. This may be a pick-and-place task. It may be welding a bead. It may be spray painting a surface. When the task no longer needs doing, the robot is reprogrammed to complete a different type of task.

Programming a robot

A robot may be programmed several ways. It is often done with a special control device called a *teach pendant*. This device uses a computer to walk the robot through the actions it will perform. The robot's memory stores the sequence of actions. It may then repeat or play back these actions in exactly the way it was taught (programmed).

A robot may be programmed in a way similar to the way NC machines are. That is, a computer is used to encode a program that is used to direct the robot's actions.

Robotic movement

Robots, Fig. 28-11, move in specific ways. They may be classified according to how they move. The groups can be defined by a coordinate system that best describes this movement. These include:

- *Rectangular* or *Cartesian coordinate system:* The robot moves on three linear axes, X, Y, and Z. A series of slides allow it to move in a straight line. The outline of the robot's possible movements forms a rectangular box.
- *Cylindrical coordinate system:* The robot has slide action for its vertical and horizontal movement. It will pivot on a center post creating a cylindrical motion. The outline of the robot's possible movements forms a cylinder.
- *Spherical* or *polar coordinate system:* The robot will pivot on its vertical and horizontal axes. The robot arm will extend and retract. The outline of the robot's possible movements forms a shape described by part of a sphere.
- *Revolute, jointed,* or *articulated coordinate system:* The robot will pivot on all three axes. This action most closely resembles the arm and shoulder movement of a human. Therefore, this type of robot can perform the most complex operations.

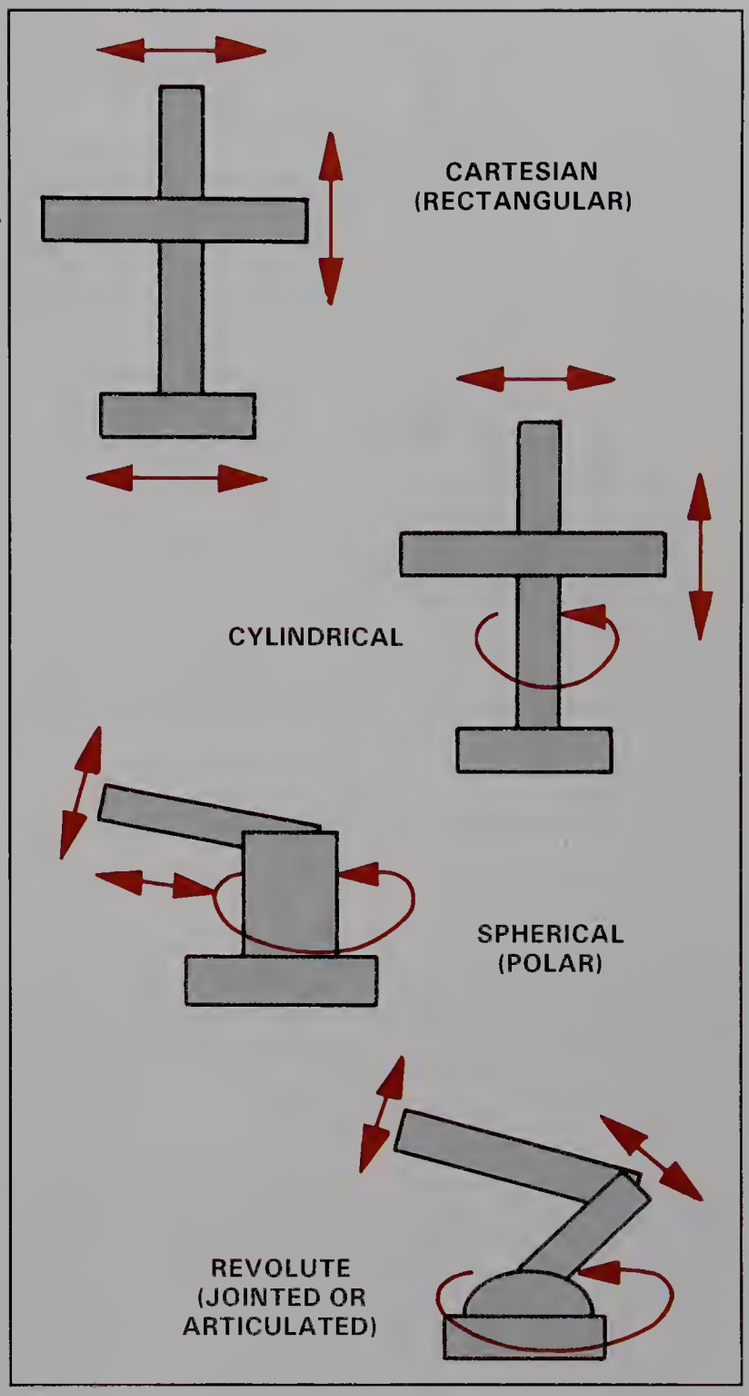


Fig. 28-11. There are four types of robot movement.

End effectors

Robotic **end effectors** are the tools at the end of a robot's arm that do the actual work. Robots may be classified into groups according to the type of end effectors they use. The most frequently used fall under two broad categories: *grippers* and *special-purpose*. Grippers, as the name implies, are used for gripping an object. Types of grippers include grasping, hooking, scooping, as well as adhesive, vacuum, and magnetic. Special-purpose end effectors are used for welding, painting, and sanding. They are used for

drilling, grinding, polishing, deburring, and nut and screw driving. They are used in inspection operations for measuring as well.

FLEXIBLE MANUFACTURING SYSTEMS

A system that integrates computer-controlled machines and material handling equipment with manufacturing control (production control, quality control, etc.) systems is called flexible manufacturing system (FMS), Fig. 28-12. FMS may include NC machines and robots connected by automatic material handling devices.

FMS allows companies to make products in small lots, yet with the cost advantages of continuous manufacturing. Computers control machine operations and adaptive control, material movement, inspection activities, and other segments of the operation. If the process fails to maintain quality standards, internal sensors and controls will shut it down and call for help.

Closely associated with FMS is *group technology (GT)*. This practice was developed a number of years ago. It groups products and parts that have similar manufacturing requirements together so that they may be manufactured in small lots. GT allows the departments or factories making the parts to concentrate on producing quality items with a minimum of equipment and required skills.



Fig. 28-12. This self-monitoring, high-speed FMS will machine both automotive and truck water pumps. (Ford Motor Co.)

Many flexible manufacturing systems depend on manufacturing cells, Fig. 28-13. A **manufacturing cell** is a small group of machines connected by a material handling system. Often, the individual elements of the cell are computer-controlled to increase flexibility and efficiency.

MANAGEMENT INFORMATION SYSTEMS

Computers were originally designed to process data. Therefore, it is not surprising that they are used for this type of work by manufacturing companies. They are used to maintain financial records, process sales orders and reports, and prepare invoices and shipping orders.

In product manufacture, computers are playing an ever-increasing, management support role. Computerized systems of information processing help achieve peak operational efficiency. These are **management information systems**. Four important systems are:

- Computer-aided process planning.
- Material requirements planning.
- Manufacturing resource planning II.
- Just-in-time manufacturing.

COMPUTER-AIDED PROCESS PLANNING

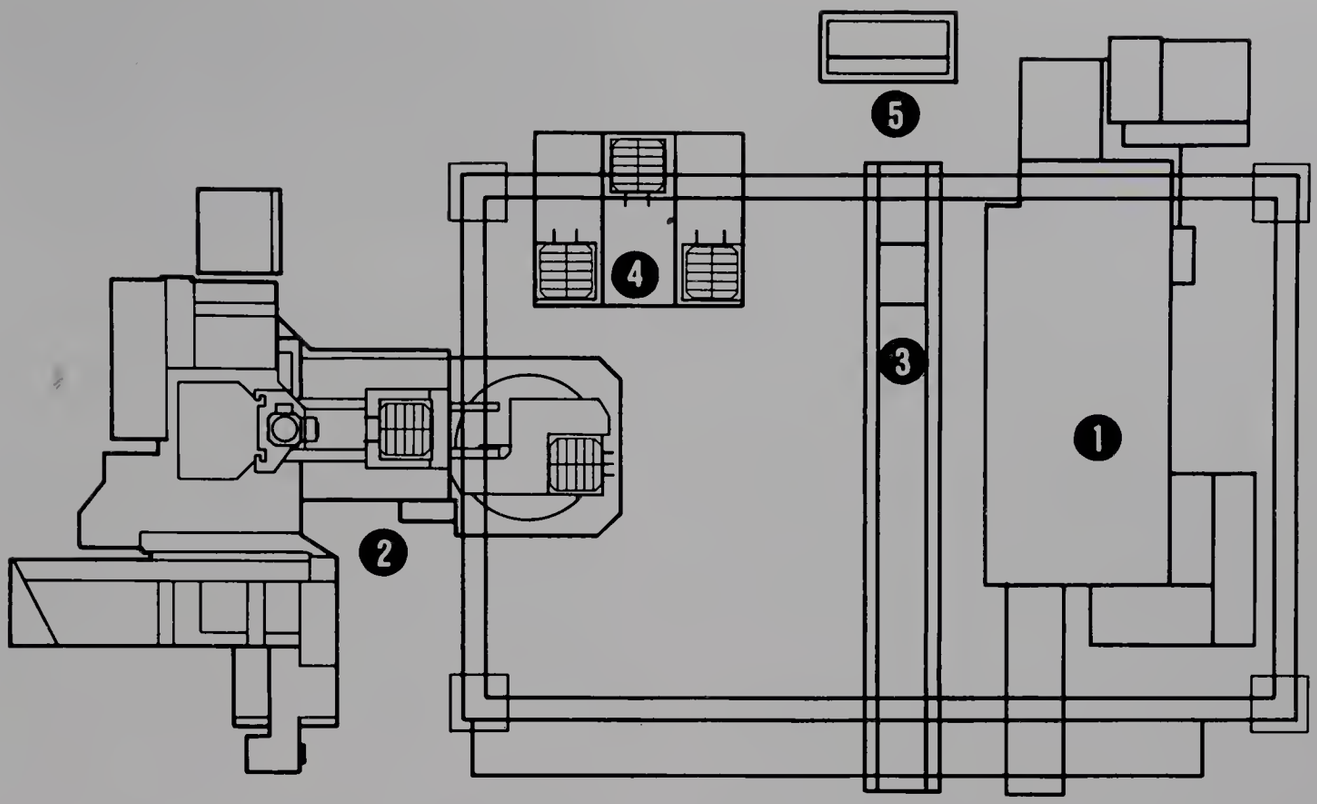
As you learned earlier, process planning involves determining production methods then selecting and sequencing operations. Expanding on this, it also involves:

- Determining the operations to be used to manufacture a product.
- Selecting the equipment that will be used for each operation.
- Determining the tooling requirements for each machine operation.
- Developing a logical sequence for the operations.

Computer-aided process planning (CAPP) allows the methods engineers to complete these tasks efficiently. It enables them to see the total operation as an integrated system. It coordinates all tasks associated with the manufacturing process.

CAPP requires a large, computer data base. It must have stored information about material properties; machine characteristics and capacities; tooling geometry; processing effects on material surface finish, mechanical properties, and dimensions; etc. This data is used to determine the optimum method of manufacturing and assembling the product.

CAPP is used to generate production schedules, flow charts, routing sheets and a number of other



1. CNC TURNING CENTER
2. CNC MACHINING CENTER
3. GANTRY-MOUNTED CNC 5-AXIS ROBOT
4. 3-POSITION LOAD/UNLOAD STATION
5. CONTROLLER



Fig. 28-13. The illustration above is a schematic of the manufacturing cell shown below. The manufacturing cell shown has a turning center and a machining center with a gantry robot loader. (Cincinnati Milacron)

process planning documents. It allows for easy modification of these and other similar planning tools.

MATERIAL REQUIREMENTS PLANNING

Material requirements planning (MRP) is part of a complete, manufacturing resource planning system. It allows schedulers to place priorities on material and parts to be produced. The priority is based on production schedules or customer orders.

Products are divided into parts based on material requirement priority. Required material is obtained from the bill of materials stored in the computer file. The computer then schedules delivery of material resources (raw materials, industrial goods, tooling, etc.) needed to produce these parts. It also maintains work-in-progress and inventory records.

MANUFACTURING RESOURCE PLANNING II

Manufacturing resource planning II (MRP II) is a complex, computer-based system that goes well beyond MRP. MRP II not only performs the functions of MRP, it produces production schedules, monitors production performance, and records manufacturing outputs.

JUST-IN-TIME MANUFACTURING

Just-in-time (JIT) manufacturing is a fairly new, computer-based monitoring system. It was developed in Japan. The JIT philosophy stresses the effective use of resources. Its focus is on eliminating tasks, such as transportation, inspection, and storage, which are thought to be wasteful. Raw material is scheduled to arrive *just in time* to be manufactured into parts and products. Parts are scheduled to be produced *just in time* to be assembled into products. Products are scheduled to be produced *just in time* to meet customer delivery orders. At all stages, inventory levels are reduced to the absolute minimum. This saves time and money, which translates into lower product costs and greater company profit.

SUMMARY

Computers have become an indispensable part of manufacturing. They are used to control machines and processes and to provide management information. Manufacturing has been enhanced through NC, DNC, and CNC machines, machining centers, and adaptive control. It has been further enhanced through industrial robots, automated material handling, and FMS.

Management information systems include CAPP, MRP, and MRP II. JIT manufacturing is also a management information system. The integration of all of these systems is called CAM. When CAM and CAD are integrated the result is CIM. CIM is becoming the manufacturing method of the future.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

adaptive control
computer numerical control (CNC)
computer-aided process planning (CAPP)
contouring machines
direct numerical control (DNC)
end effectors
fixed sequence robot
industrial robot
just-in-time (JIT) manufacturing
machining centers
management information systems
manufacturing cell
manufacturing resource planning II (MRP II)
materials requirement planning (MRP)
numerical control (NC)
point-to-point (PTP) machines
straight cut machines
variable sequence robot

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

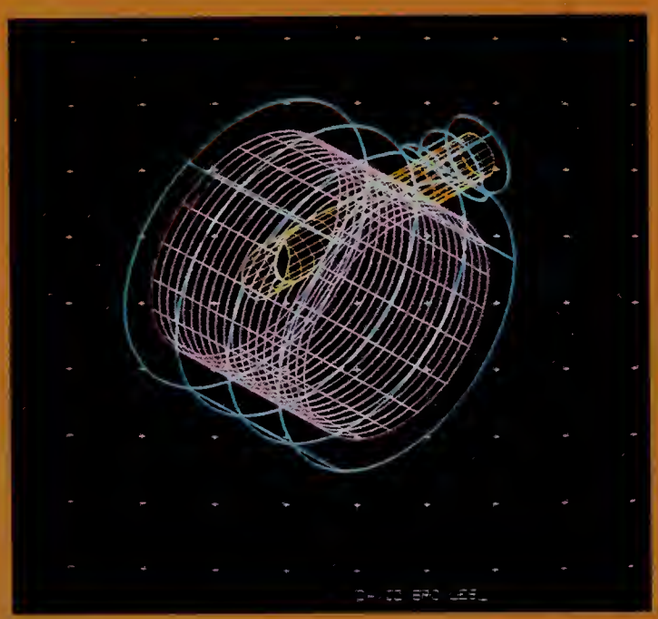
1. Two major elements of CAM are _____ and _____.
2. Which of the following is a kind of automated machine or system?
   a. An NC machine.
   b. An industrial robot.
   c. FMS.
   d. All of the above.
3. True or False? A PTP machine can move on three machine axes at the same time.
4. With regard to NC, for what reason are rectangular coordinates used?
5. _____ automatically adjusts a machine tool so that it adapts to operating conditions.
6. True or False? Robots are useful in applications where human safety is a concern.
7. End effectors may be divided into the broad categories of _____ and _____.
8. Name four important management information systems.

9. The focus of JIT manufacturing is:
   a. Development of a logical sequence of manufacturing operation.
   b. Prioritizing part production based on customer needs.
   c. Eliminating tasks thought to be wasteful.
   d. All of the above.

APPLYING YOUR KNOWLEDGE

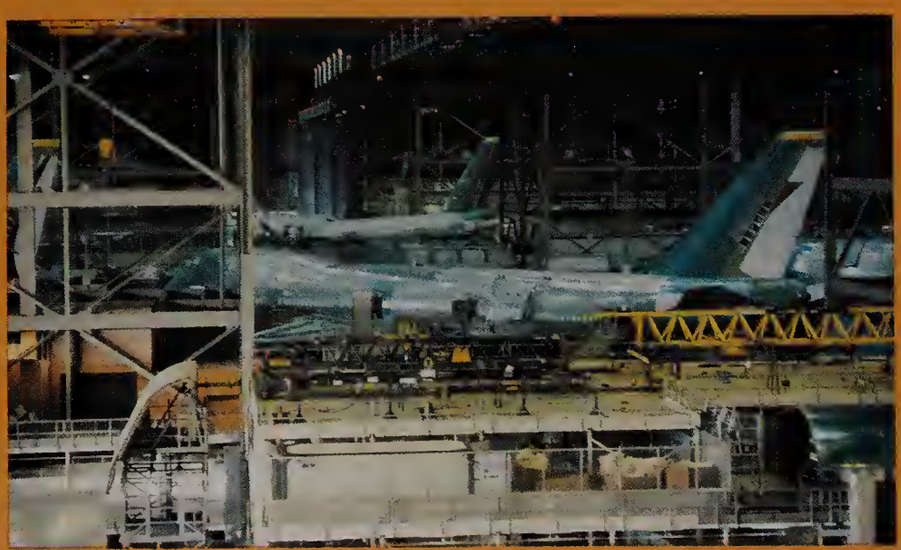
Note: Be sure to follow accepted safety practices when working with tools. Your instructor will provide safety instructions.

1. Draw X, Y, and Z axes and plot the following coordinates: (1,3,2); (-2,4,2); and (3,-2,2).
2. Visit a local manufacturing company that uses computers to control machines or provide manufacturing data. Prepare a bulletin board to communicate the information you gained from the trip.
3. Produce a simple part using a CNC machine.
4. A manufacturing cell is a series of computer-controlled machines connected by automatic material handling devices. Design a manufacturing cell for a simple product or for the one you are manufacturing in the enterprise activity.
   a. Look at the schematic of the manufacturing cell shown in Fig. 28-13.
   b. Determine what machines will be needed in order to manufacture the product you have chosen.
   c. Secure drafting or sketching paper with a grid on it from your instructor. Locate the machines on the paper and sketch them. Try to locate the machines in the best arrangement for an efficient flow from one to the next. (Note: If you wish, use simple rectangles, squares, and circles to indicate the machines and the robot.)
   d. Label all machines and robots.





GENERAL MOTORS CORP.



section 7

Manufacturing and You

29. Manufacturing, Technology, and the Future

30. Leadership, Employment, and Impacts



BARBERTON



TEXACO, INC.



Use of industrial robots, already vital to some manufacturing companies, will become more common in the future. (Cincinnati Milacron)

29

CHAPTER

MANUFACTURING, TECHNOLOGY, AND THE FUTURE

After studying this chapter, you will be able to:

- *Discuss the future trend of management.*
- *Describe the changing image of "American industry."*
- *Discuss the emerging "thinking" computer.*
- *Explain why continuing education will be so important in the upcoming years.*

Benjamin Franklin said all people could be certain of death and taxes. The future adds a third certainty–change. Throughout history, this has been true. Sometimes change comes about rapidly. In just one lifetime, animal power was replaced with gasoline engine power. Custom handcrafting was replaced with automation and mass production. See Fig. 29-1. In spite of the rapid pace, people could grow with the change. It was still moderate enough.

Things are different now and will continue to be. Change is accelerating. It is moving from *rapid* to *radical*. Change is coming so fast now, many people neither understand it nor accept it. Cynics suggest that if you understand something, it is already obsolete. This is partly true for much of the technology around us. A look at the radical advances in computer hardware and software supports this view.

We do not have to be victims of change. We can adapt and grow with it if we look to the future. You have probably heard the saying, "This is the first day of the rest of your life." It suggests that you must keep



Fig. 29-1. The telephone has changed from the original (replica) model (left) to a modern instrument (right) in just one lifetime. (AT&T Bell Laboratories)

looking to the future. That is where you are going to live for the rest of your life. It is nice to have memories of the fun times you have had. However, memories give few clues about the world in which you will be living and working. What kind of world will it be? What new technologies will emerge? What will be the role of manufacturing in this world? What will be the role of managers and workers in industry? How will products be designed and produced? See Fig. 29-2. From what materials will they be made?

These and hundreds of other questions could be asked about manufacturing and technology in the future. No one has the answers. Some people, called **futurists**, try to predict possible future conditions. They use historical perspectives and current trends to suggest future events.

There are a number of areas of manufacturing and technology that will be different in the future. For this discussion, predictions about the following will be explored:

- Emerging technologies.
- Management values and entrepreneurship.
- Materials.
- Manufacturing methods and processes.
- Products and the consumer.
- Jobs and the worker.

EMERGING TECHNOLOGIES

Technology and science, by their very nature, are constantly expanding. The next several decades will see major advances in two fields of study. These are physics and molecular biology. Work in these areas will be focused on two remaining, scientific frontiers: atomic structures and genetics.

Advances in physics will allow computers to increase in speed. Presently, they are slowed by the speed of electrons and switching gates. Use of the new fiber-optic type computer will be one way of overcoming this barrier. The other will be superconducting materials, which will offer virtually no resistance to electron flow.

New computer memories will be developed. These will be based on the human brain function. The human brain can locate data, retrieve it, and process information faster than any known computer. New silicon memory systems that can see, hear, feel, and remember will appear on the market.

Other advances in physics will expand telecommunication technologies. Fiber optics will continue to grow as a preferred channel for data and voice communications. Increasingly complex satellites will be present around the globe. Telecommunications will be within the financial reach of almost everyone.

Biotechnology, an offshoot of molecular biology, will also become a central technology, Fig. 29-3. It focuses on using organisms as part of a technological system. Biotechnology is already being used to



Fig. 29-3. Biotechnology can be used to develop stronger, faster-growing, and more disease-resistant plants.



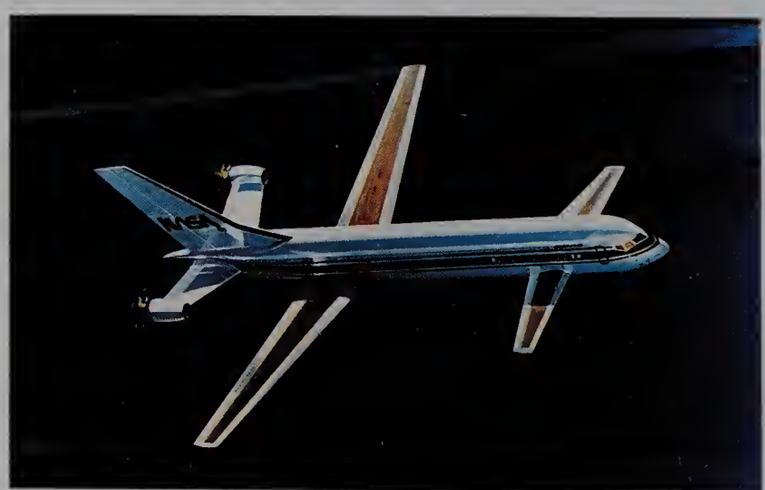


Fig. 29-2. The future will bring many new manufactured products including solar-powered automobiles (left) and radically different aircraft (right). (General Motors Corp., NASA)

develop disease resistant plants and natural pesticides. Among other things, it is being used in industrial processes and in oil spill cleanup.

MANAGEMENT VALUES AND ENTREPRENEURSHIP

Business experts are saying that many of the problems with American industry can be traced to top management. They have lacked confidence in their workers and suppliers. They have placed great value on short-term goals in the interest of favorable quarterly dividends. They have placed little value on long-term growth. Investments in product development and plant and equipment upgrades have been neglected. This problem is being addressed and a promising new type of business is developing. It is known as entrepreneurship.

The future should be bright for a new breed of owner/managers–the daring entrepreneurs of the future. There will be venture capital (initial start-up money) to finance new ideas and companies. These new entrepreneurs will have high levels of self-confidence. They will be willing to take risks. Likely, they will not have lived through a depression, which causes people to be financially cautious. The new business titans will not be driven solely by financial success. They will take financial risks for the challenge of pushing the enterprise system to the limit.

These people will organize and develop a number of small companies. They will develop new products quickly. They will abandon older, less-profitable products just as quickly. These companies will generate the majority of new manufacturing jobs in the future. The large manufacturing giants of today will be present but rather stagnant.

This entrepreneurship will be coupled with new management styles, Fig. 29-4. Most successful companies will practice participatory management. There will be fewer layers of management between the owners and the workers. The workers will have significant input to managerial decisions. They will be expected to accept higher levels of responsibility in their work for the success of the company.

MATERIALS

Many materials are becoming scarce. The supply of copper, lead, and mercury could be exhausted during the twenty-first century. Likewise, major fuels, such as petroleum and natural gas, are being depleted. New materials and energy sources will be developed as replacements. A wave of the future will be engineered materials.

Historically, products and structures were engineered to fit a material. For example, home builders chose the size of rafters in terms of the span and the expected dead load (weight of roof and snow). Longer rafters had to have a larger cross section. They were made from 2 x 6s instead of 2 x 4s. Likewise, larger metal parts were made of thicker steel to provide more strength. The characteristics of the material dictated many design solutions.

The future will see material engineered to meet product demands, Fig. 29-5. Flexible glass that bends without breaking, metals that stretch, and plastics that are as tough as steel have been developed.



Fig. 29-4. Entrepreneurship and participatory management will bring the manufacturing team (workers, technical people, and managers) closer together.

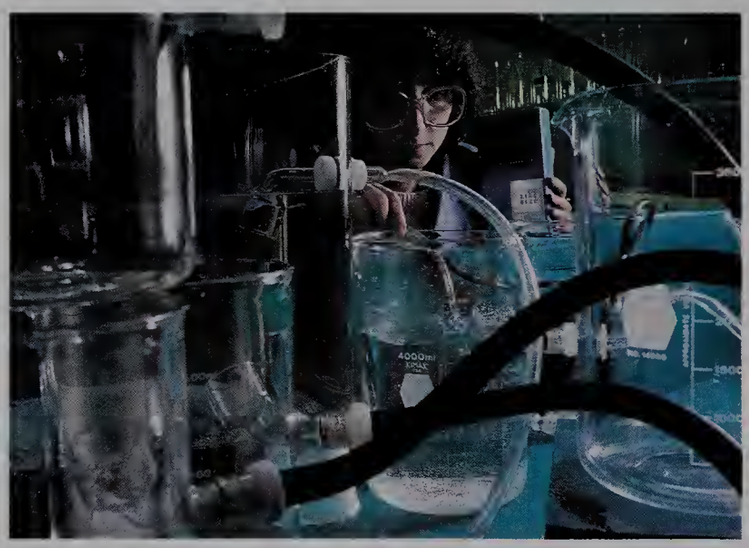


Fig. 29-5. Laboratory research will develop new manufacturing materials. (PPG Industries)

Ceramics, a favorite material of primitive humans, are finding their way into such products as space shuttle heat shields and tooth implants.

Plastics and composites (especially, ceramic and plastics reinforced with synthetic or carbon fibers) will be the new materials of choice. They will replace metals in many products. These new materials have some exceptional qualities, one of which is tolerance of high temperature. Plastics have been developed that can withstand 600°F (316°C). Newer composite materials can endure temperatures as high as is found in most types of combustion chambers.

Products will be designed to use less material. Currently, Americans use about 10 tons of nonrenewable materials per person per year. This is causing a strain on the world's natural material resources. It must be and will be reduced. Products will be made lighter. Obsolete goods will be recycled.

New and improved technologies will supplant existing and reduce the amount of material required. Communication is already a case in point. The Transatlantic Cable used 150,000 tons of material. A communication satellite uses only 500 lb. of materials, and also provides better communication service!

MANUFACTURING METHODS AND PROCESSES

American industry dominated the world for nearly a century. The country successfully mechanized manufacturing, agriculture, mining, and forestry. The picture of "American industry" used to conjure up images of workers doing repetitive tasks in dark and dingy factories. Thoughts of people looking bored or wiping their brow were brought to mind. This has all changed. Industry is gaining a new image because of the new wave of change. Mechanization has been largely enhanced by automation. The image of the future is of a gleaming workplace with highly skilled technicians and state-of-the-art machines.

Almost everyone who describes manufacturing in the future tells of a greater use of computers, automated machines, and industrial robots, Fig. 29-6. On the horizon are "thinking" computers. The name assigned to this branch of computer science is **artificial intelligence (AI)**. A branch of AI is called *expert systems (ES)*. Both of these systems can perform human-like activities. They have the ability to reason. They can see, hear, and feel. They can interpret audio and visual data. Like people, AI uses the senses to gather information. The computer then processes the sensory information and acts upon it. ES features the ability of a computer to function on "learned" rather than programmed operations and data. These systems will be used in manufacturing to monitor processes, check quality, and direct machines and material handling devices (robots, AGVs, etc.).

CIM will become common. Products will be conceptually designed, manufactured, and marketed on the computer well before actual production begins. Every step of manufacturing will be interconnected by computer systems. Designing, engineering, manufacturing, quality control, purchasing, financing, and marketing will be integrated into one system.

In another arena, manufacturing will live in better harmony with the environment. In some cases, waste from one process will be the raw material of another. Materials will be recycled after they serve their useful life. Discarded metal cans could become the base materials of automobiles. When worn out, these cars could become the structural steel of high-rise buildings. This type of system would create an industrial ecosystem much like the biological ecosystem of the earth. There would be a constant recycling of materials. This type of system is becoming essential as the demands of our rapidly growing global population accelerate.

Manufacturing will move beyond its traditional bounds. Experiments of manufacturing in space are now being performed. A leading manufacturer of agricultural equipment is a major participant in space research. It is using the low gravity environment of space to conduct research on the microstruc-

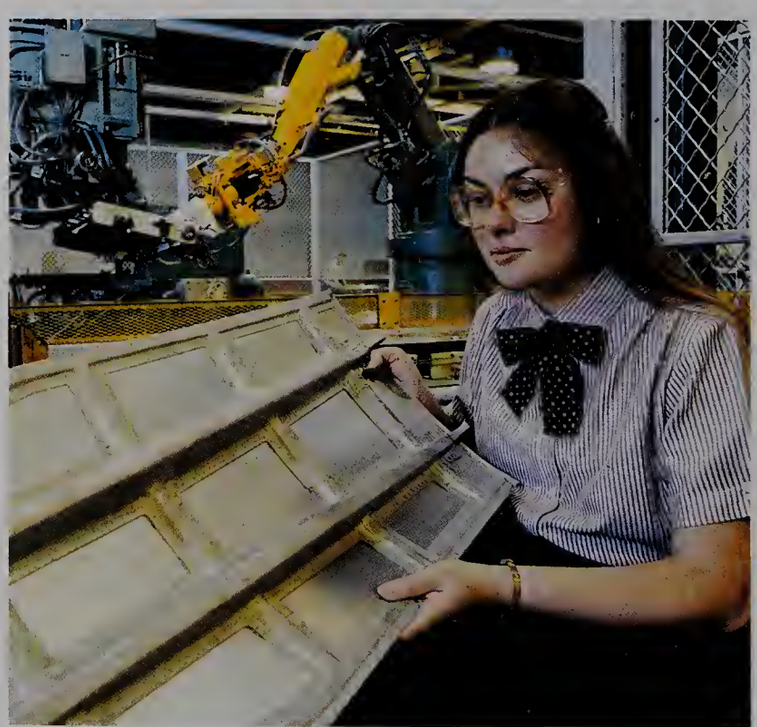


Fig. 29-6. Industrial robots, like the one in the background, will be increasingly important to manufacturing companies. (General Electric Co.)

ture of iron. This environment allows for a better study of what happens when molten iron solidifies. The results of the research may help the company improve its iron-casting techniques. Another experiment involves growing organic crystals from organic solvents.

As a result of these and other experiments, some manufacturing processes will move into space, Fig. 29-7. This environment will allow for better process control. Weightless and pollution-free environments will improve many processes. Recently, perfectly round spheres were manufactured in space. These beads have become essential for calibrating delicate laboratory measuring instruments.

Manufacturing in space will thrive. One estimate suggests that by the twenty-first century, several billion dollars worth of pharmaceuticals and electronic materials will be manufactured in space. Earthbound manufacturing will not go away, however. It will still flourish.

PRODUCTS AND THE CONSUMER

The products of the future will be world-class. They will be high-quality and low-priced. Quality will become a central issue, because the average consumer will accept only quality products. Those companies producing this type of product will remain competitive. They will significantly lower costs by reducing scrap and the need for repairs. Today, these costs can run as high as 30 percent of production costs.

Also, these products will be global. The parts will be manufactured in many countries. Manufacturing will move around the globe as economic conditions change. Labor intensive (requiring large amounts of human labor) products will be made in densely populated, poorer nations. High-tech products will be the domain of developed countries. Manufacturing efficiency will be the key to economic survival of every country.

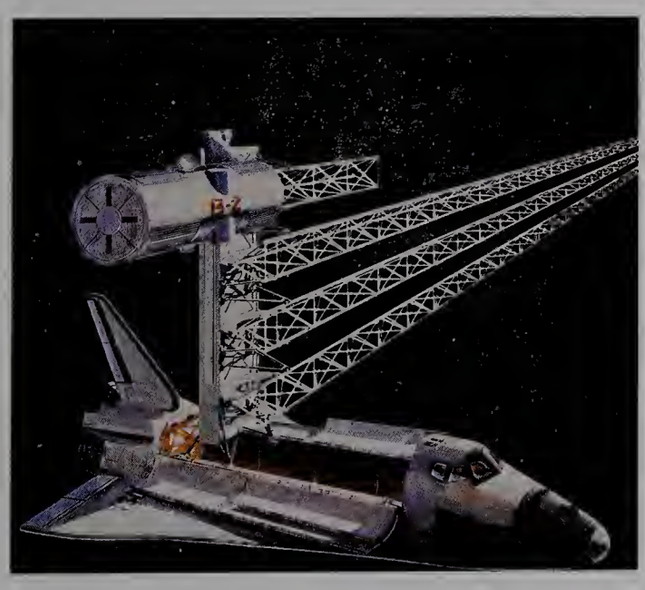


Fig. 29-7. This is an artist's idea of what a "space factory" might look like. (NASA)

Products will be a paradox between simple and complex. They will continue to be technologically more complex. However, they will be simpler to fabricate and assemble.

JOBS AND THE WORKER

Employment involving the actual manufacture of products will continue to decline as a percentage of the total work force. Service industries presently account for about 70 percent of all jobs. Their numbers are projected to grow until they account for more than 90 percent by the year 2000. It is also projected that 50 percent of all service jobs will be in the computer field of information processing. Many of these service jobs will be related to manufacturing. They will be directed at the designing, the producing, and the marketing of products (without involving the actual, physical manufacture of products).

Automation will cut the ranks of the blue-collar worker. Jobs for machine operators, which are traditionally well-paying and require limited skills, will continue to shrink. They will be replaced by the "steel-collar" worker–robots and other automated machines. The blue-collar worker will have two choices: accept lower paying jobs or upgrade education and skills.

The jobs with a future will involve technology and science. Both of these fields are rapidly changing. Job-related knowledge will quickly become obsolete. The half-life of engineers (the point at which one-half of their knowledge is obsolete) is three to ten years. Technicians and technologists face the same problem. This will dictate the need of employees to continually involve themselves in training programs and other educational activities.

Nearly all jobs will require at least a high school education. The majority of new jobs will be white-collar positions. They will be mostly managerial, technical, or scientific in nature. People possessing computer skills will be in demand. The best-paying jobs will require creativity, decision-making abilities, and human relations skills, Fig. 29-8. Almost universally, they will require post-high school training. There will be few meaningful jobs for high school dropouts.



Fig. 29-8. Jobs requiring creativity and imagination will always be in demand.
(Motor Vehicle Manufacturer Association)

Coupled with the change in job demands will be a continued loss of membership in labor unions. Traditional strongholds of organized labor, the factory worker and miner, will weaken. The new scientists, engineers, and technicians will not readily join unions. This will create a new work environment. The "us" and "them" (labor and management) attitude will disappear.

SUMMARY

New technologies in the fields of physics and molecular biology are emerging. Superconducting materials, humanoid robots, and genetic manipulation will be in the forefront of technology. The future should bring a change in management values. Entrepreneurs will start up small companies. They will be dynamic and profitable. Larger companies will be present but will stagnate. High-quality engineered materials will be developed.

Manufacturing methods and processes will change. The image of a dirty factory will become one of a gleaming workplace run by high-tech machines and people. AI and CIM will be common. Goods will be recycled. Products will be manufactured in space. Manufacturing will change globally. Products will be better quality.

Jobs will become more service oriented, less manufacturing oriented. These new technologies will demand highly trained people. There will be no meaningful work for the unskilled or semiskilled worker or for the high school dropout. Summing up, the future in manufacturing, as always, promises change; it promises to be interesting.

KEY WORDS

All of the following words have been used in this chapter. Do you know their meanings?

artificial intelligence (AI)
futurist

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. True or False? Change in the future will occur at the same pace as it occurred in the past.
2. Biotechnology, an offshoot of molecular biology, is being used:
   a. To develop disease resistant plants and natural pesticides.
   b. In some industrial processes.
   c. In oil spill cleanup.
   d. All of the above.
3. Small companies, formed by a new breed of owner/managers called _____, will generate the majority of new manufacturing jobs in the future.
4. True or False? The workplace of the future will have highly skilled technicians and state-of-the-art equipment.
5. Some computers of the future will be able to:
   a. Reason.
   b. Learn.
   c. See, hear, and feel.
   d. All of the above.
6. Explain why continuing education beyond high school will be so important in the upcoming years.

APPLYING YOUR KNOWLEDGE

1. Develop a bulletin board showing changes seen in your life and in the lives of the nearest two generations before you.
2. Select a product. List the materials in it that have been developed in the last 50 years.
3. Examine a product of your own choice.
   a. Identify the materials of which it is made and list them on a sheet of paper.
   b. Research the history of the materials using information found in the resource center or school library.
   c. Indicate on the sheet which materials in the product have been developed in the last 50 years.
   d. Report your findings to the class.

30
CHAPTER

LEADERSHIP, EMPLOYMENT, AND IMPACTS

After studying this chapter, you will be able to:

- *Explain the difference between leadership and control.*
- *Explain three principles shared by effective leaders.*
- *List seven elements of an effective plan.*
- *List five general considerations to help you choose the right job.*
- *Discuss details you should consider before making a purchase.*
- *Apply manufacturing lessons to everyday life skills.*

Much of what has been learned about manufacturing is concerned with group efforts–groups of managers directing groups of operations and groups of employees. It is relevant at this point to discuss how manufacturing relates to you–the individual, Fig. 30-1. You may wonder, "What role can I play in manufacturing? What lessons related to manufacturing can I apply to my own life?" This chapter attempts to answer these questions.



Fig. 30-1. Individuals serve manufacturing in leadership, general employment, and consumer roles.

LEADERSHIP

Leadership is a vital part of manufacturing. It is equally vital in other aspects of your life. **Leadership** is the leading or guiding of others. A key to good leadership is having the ability to inspire all kinds of people to work together.

Some people equate leadership with giving orders or directing people and demanding results. This is actually *control*. Leadership and control are not the same thing. Prison guards exercise control. They

strongly direct and monitor the actions of people. Leadership, on the other hand, connotes a more positive, guiding approach at reaching desired results.

Effective leaders employ the ideals of participatory management. Striving to maintain an open atmosphere, they involve all group members in the decision-making process. They value input from every person. See Fig. 30-2.

Effective leaders are good at getting things done. Effective leaders share common principles in regard to leadership that help them reach their goals. These are:

- A *"team" attitude.*
- A *shared vision.*
- A *plan of action.*

TEAM ATTITUDE

Leaders know that group success depends on developing an effective team. Effective teams have some common characteristics.

First, the members have *mutual respect* for each other. Differing opinions are respected and welcomed. A good team will have differences and even heated arguments. However, in the end, the members will remain friendly and cooperative.

Second, an effective team is made up of people who have *specific knowledge and talents*. Each person brings different ideas and skills to a group. When unified, the overall effectiveness of the team is greater than the sum of the ideas and talents contributed by the team *members*. This phenomenon is called **synergism**. It is a state wherein the whole effect is greater than the sum of the individual effects.



Fig. 30-2. Effective leadership employs the ideas and skills of every individual. (American Petroleum Institute)

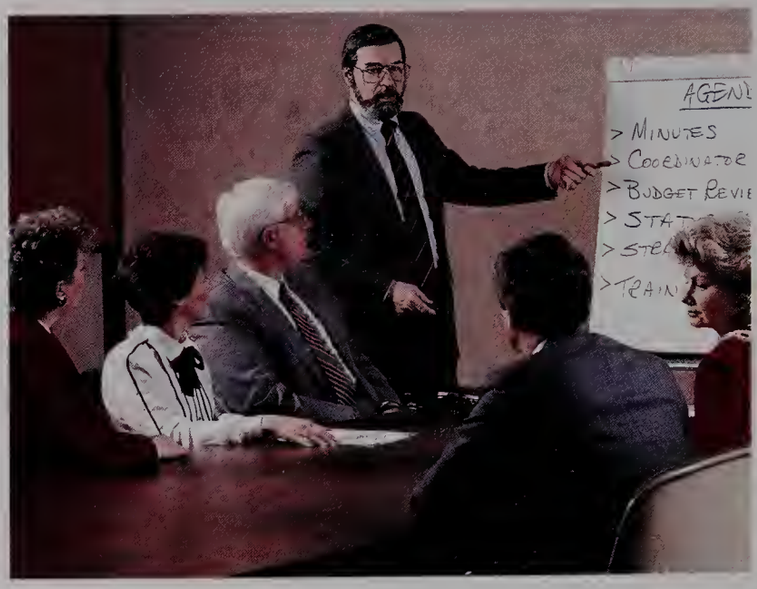


Fig. 30-3. Effective groups have appointed or selected leaders. (Federal Mogul)

Third, an effective team has a *designated leader*, Fig. 30-3. This leader should be enthusiastic and have a positive attitude. He or she should be the "cheerleader" for the group. The leader should encourage and reinforce the success of each group member.

SHARED VISION

Leaders know that group success depends on a shared vision. The leader and the team members must want the same results. Our nation's space program provides a good example of this. See Fig. 30-4. President Kennedy said that an American would walk on the moon within a decade. It happened because thousands of people were taken up by the challenge. They shared the vision of an American walking on the moon and were willing to strive for this vision. They worked long hours–gave up hobbies, vacations, and other pursuits. Such dedication helped Neil Armstrong become the first person to walk on the moon.

Getting people to share a vision is not always easy. The key is for them to see personal benefit in pursuing the vision. Leaders sometimes make appeals to the workers' sense of pride or loyalty in trying to obtain their support.

Have you ever watched an outstanding school band? The band members share a vision–putting on a good show for the audience. The members take pride in their music. They receive satisfaction from the applause. They are loyal to the same school and want to promote school spirit through music. Finally, all the members benefit from the experience and friends they gain while playing in the band.

PLAN OF ACTION

Few things of value get done without a plan of action. Columbus *planned* to sail around the world. Rembrandt *planned* to paint great pictures. George Washington *planned* to win the Revolutionary War. Lee Iacocca *planned* to set a new course for the Chrysler Corporation.

Leaders also operate from a plan. They help the group set goals and a course of action. This is best done by working with the group and guiding them instead of issuing a predetermined plan. Guiding people is always easier when they understand and accept the overall goal.

An effective plan:

- Sets goals and deadlines for an overall job.
- Establishes and organizes specific tasks.
- Challenges members to accept portions of the job.
- Completes the job within a given time frame.
- Monitors progress and compares it to an approved schedule.
- Determines corrective actions to be taken when problems arise.
- Rewards members with praise, money, or other incentives for completing tasks and overall job.

A good leader helps people to become team members, establish a vision, and develop a plan of action. With these elements in place, the group is better positioned to succeed at the job before them.

EMPLOYMENT

Working for a living can be challenging and rewarding, Fig. 30-5. Everyone has some basic needs that can be fulfilled by working. We need to have money to pay our bills. We want to be able to buy goods and services. We need to have savings to give us security.

However, money does not fulfill all of our wants and needs. People generally want to be needed. They want to be important in the eyes of others. Most of us feel better if we belong to a group, contribute to its success, and are recognized for our contributions. Working is one way a person we can do this-being a contributing family member is another. Spouses can contribute to the family. People can contribute, both time and money, to religious groups, service clubs, charity organizations, and governmental agencies.

CHOOSING THE RIGHT JOB

The arena of manufacturing is a major source of employment. Manufacturing jobs use a diverse range of human talents, Fig. 30-6. Some jobs require high levels of scientific and mathematical knowledge. Other jobs require artistic abilities. Technical skills are required of technicians, maintenance workers, and machine operators, to name a few. Managerial skills are needed by all workers; however, they are

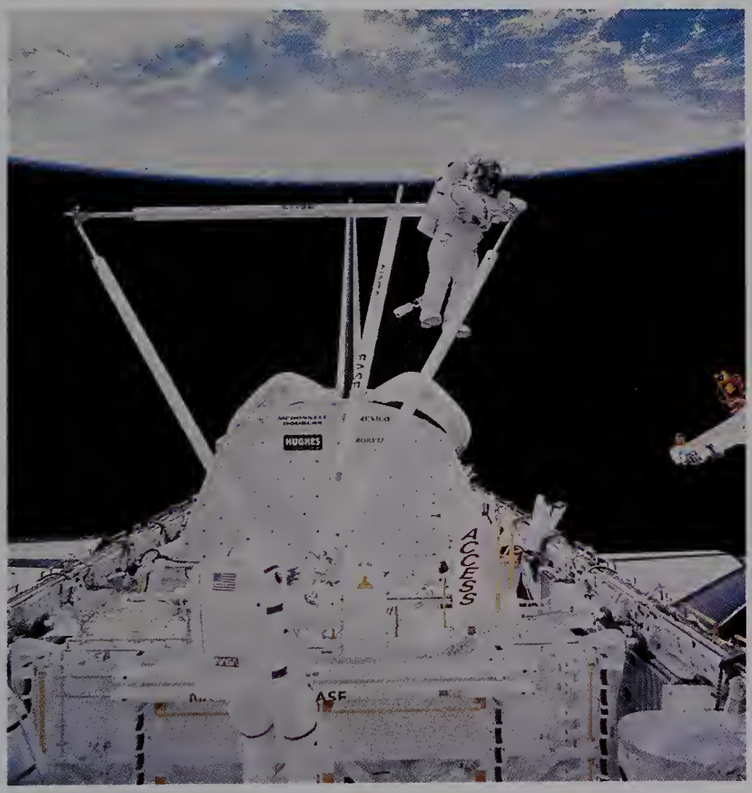


Fig. 30-4. The American space program depends on thousands of people sharing the same vision. (NASA)

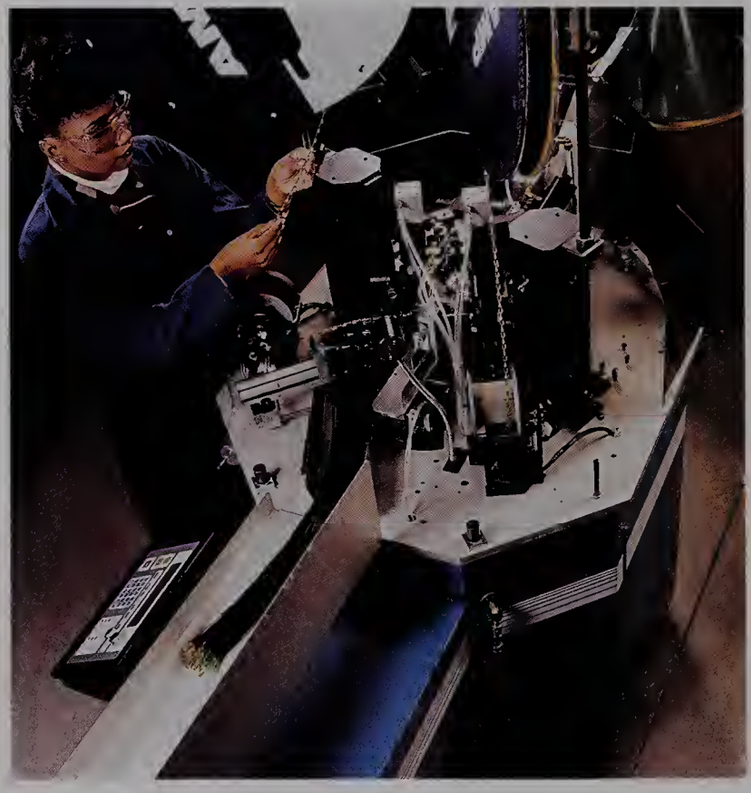
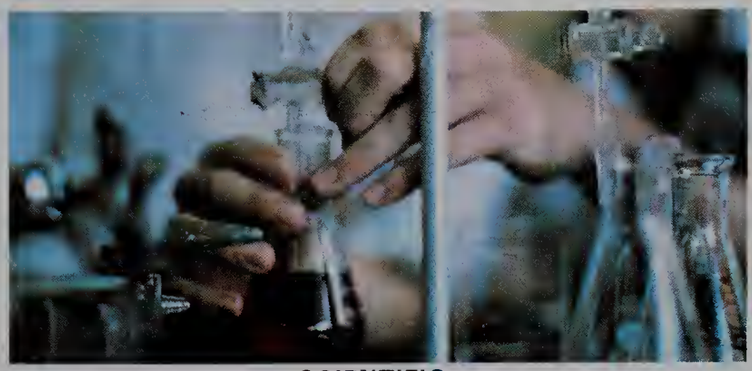
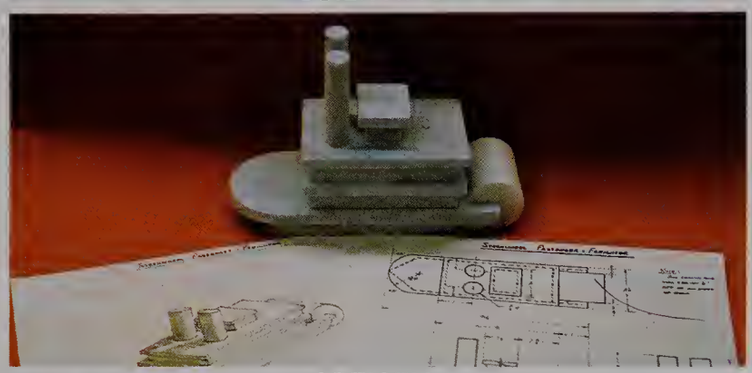


Fig. 30-5. Manufacturing careers can be challenging and rewarding. (AMP Inc.)



SCIENTIFIC



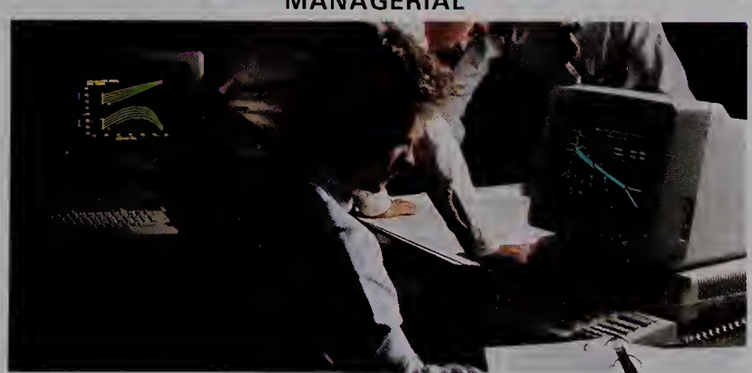
ARTISTIC



TECHNICAL



MANAGERIAL



HUMAN RELATIONS

Fig. 30-6. Manufacturing requires a diversity of talents. (Zenith Electronics Corp., Ohio Art Co.)

particularly important for supervisors and higher-level managers. Human relations or "people" skills are needed by almost everyone in a company. No job is isolated from other people. We must all work together and get along.

Like other careers, manufacturing careers should be carefully selected by the prospective worker. A major share of life will be spent working. Therefore, it is unwise to settle for just any job. It is unfortunate to have a job that fails to provide satisfaction.

Selecting a job that will suit personal goals is not an easy task for most people. It involves research. It involves careful consideration. To be satisfied, you must choose a direction based on what you know about yourself and what you have learned from your research. Consider the following and weigh the importance of each before choosing your direction:

- Market demand.
- Job demands.
- Personal traits, interests, and abilities.
- Educational requirements.
- Life-style.

Market demand

It is a good idea to look into the market demand of the jobs that are of interest to you. Find out how hard it would be to find employment in them before obtaining special training or additional education. There may already be a glut of people in the field of your choice or there may be simply no need for a certain specialty. Unless you are focused on a particular field, if the demand is not there, consider an alternative job. It would be a shame to spend time pursuing additional training if you could not find a job in the area in which you trained.

If, in spite of lacking job opportunities, you still strongly favor a certain job, by all means, pursue it. You may have to search harder to find a position. Yet, the rewards of working in a job that you really like can make the effort worthwhile.

Job demands

Consider the demands of the job. Manufacturing jobs can be analyzed by what they require of the worker. Most jobs require employees to work with a variety of people, machines, materials, and data, Fig. 30-7. However, assembly people work largely with machines and tools. Accounting people process large quantities of data. Salespeople meet other people constantly. Labor jobs can be physically demanding and require good physical condition.

Some jobs require continuing education on and off the job. Other jobs are stressful. Some have fixed



Fig. 30-7. Manufacturing attracts people because of the balance between working with people, data, and things.

work hours while others involve long hours or frequent overnight travel. If the demands of a job do not appeal to you, consider something else.

Personal traits, interests, and abilities

A manufacturing job should be matched to personal traits, interests, and abilities. People who like active work, as opposed to desk work, may select a job in plant maintenance. People who like mechanical things might select jobs in engineering design or product manufacture. People with artistic ability might seek jobs in advertising, product development, and package design. Friendly, outgoing individuals might want to pursue jobs in sales or public relations. Analytical people, who like detail, may be attracted to research, accounting, finance, and quality control positions.

Opportunities exist in manufacturing for skilled workers. These people can work as machinists, assemblers, tool-and-die makers, and cabinetmakers. They can also work as metalworking, plasticworking, and NC machine operators. High school courses in technology, mathematics, and science, and a mechanical aptitude are helpful for people who would like to pursue careers in these occupations.

Educational requirements

Almost all jobs have educational requirements. Most jobs require a high school diploma. Other jobs might require a master's or even a doctorate degree. Personal abilities (mechanical, analytical, artistic, etc.) are usually not enough to get by on for most jobs. They need to be enhanced through furthering education.

If you have a particular area of interest, consider the education that is required. Consider how much time and effort you are willing to spend in its pursuit. If you have a particular job goal, it is best to go after it. If hard work is required to obtain it, stay determined. You may get discouraged at times, but the satisfaction you will receive in accomplishing your goal will make all of your efforts worthwhile.

The amount of education you receive can determine at what level of a particular field you may work. For example, different jobs that involve mechanical skills require different levels of education. Machine operators generally need a high school education. Robot repair personnel may need an associate (two-year) degree. Mechanical design engineers usually have a bachelor's (4-year) degree. The person who wants to manage the company's mechanical division, in many cases, needs a master's degree.

The chart in Fig. 30-8 shows a relationship between jobs and their educational requirements. The diagram can be summarized by these points:

- You can generally enter the working world at a higher level of responsibility if you have completed a higher level of training.
- There are many kinds of schools, and you can move from one to another.
- You can move from one school to the working world and return to schooling at the *next* level. You can also return to the same level of schooling in another field of study.
- You can enter the working world at any level that you have prepared to enter. You can then advance by taking advantage of opportunities to improve your skills on the job. Usually, however, there are limits to how far you can advance by this method.

Life-style

Employment has a direct effect on a person's life-style. Choose a job that will fit yours. Determine how much money you need to support your life-style. Determine where you would like to live. How will you spend your leisure time? Do you like city life or rural life? Are you an outdoor-type person? If so, do you like summer, or winter activities? What kind of climate do you like? Also, determine if the type of life-style you want will permit a job which requires overnight business travel or long hours.

BEING SUCCESSFUL ON THE JOB

Suppose that you have done your homework and you have landed the job of your dreams. You may wonder what you can do now to be as successful on

the job as you have been in your job search effort. Key to being successful on the job lies in your attitude. Have a positive attitude. It will affect your productivity. It will affect productivity of others. Attitude is closely related to ability to get along with people.

Getting along with others requires more than getting people to like you. You need to know how to handle certain "sticky" situations. Human relations skills are vital. You should know how to deal with the unfair supervisor, the harassing co-worker, or the office "gossip." You have to understand yourself and others. Being smart about getting along with others does not mean being insincere or a phony. The person who understands human relations tries sincerely to develop friendly, honest, and open relationships with all co-workers.

The successful employee tries not to irritate others. Poor grooming habits are offensive and will likely irritate other employees. Cleanliness and proper appearance is important. It will affect your attitude. If you are clean and properly dressed, chances are you will feel good and others will notice your positive attitude. You will likely be more productive. Your co-workers will have more respect for you. Your supervisor will perceive you more favorably. Always dress for success.

There are many other habits that can irritate people. Speaking or yelling in a harsh, whining, or loud voice is one. Bragging is another. The list can be quite

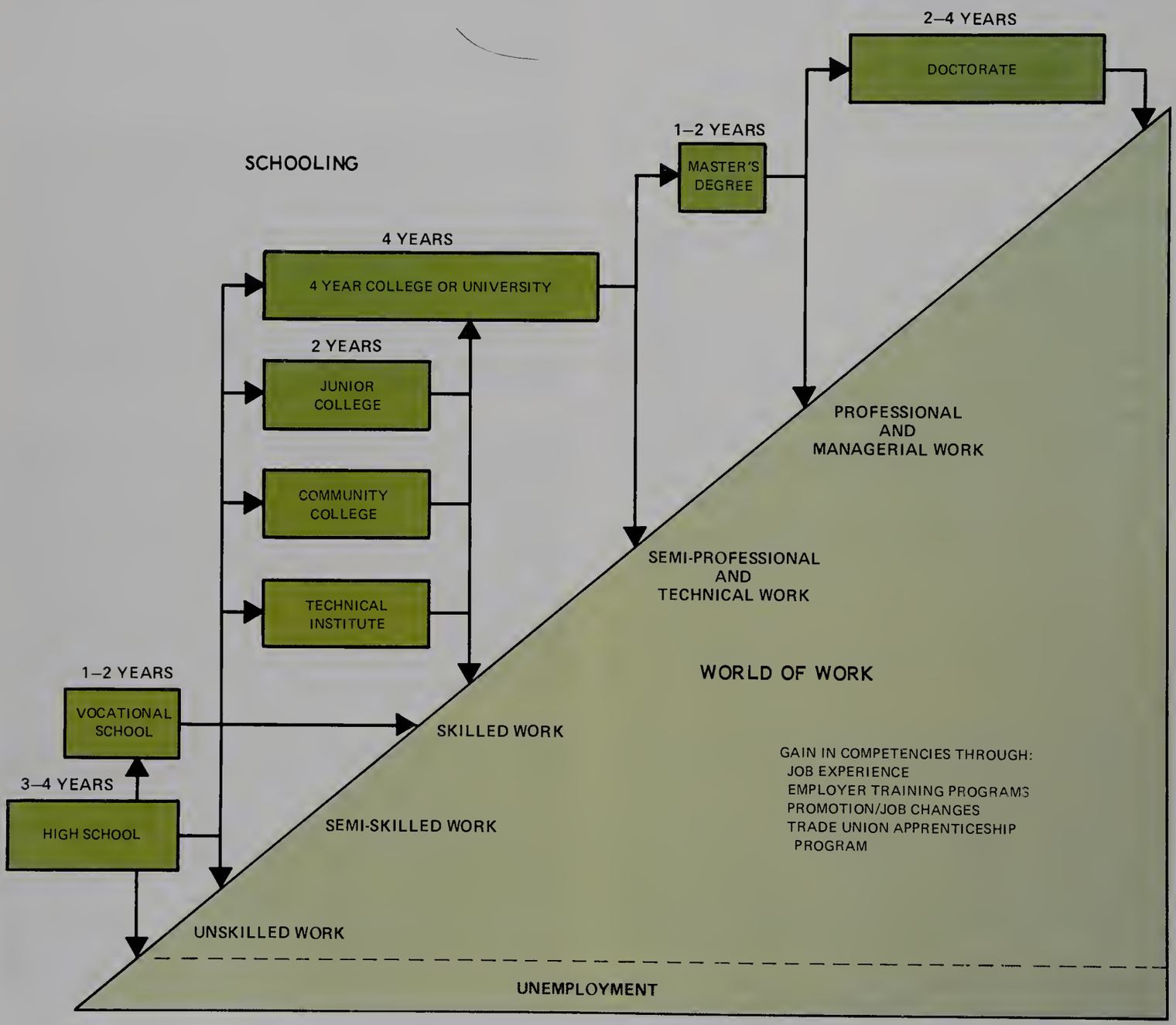


Fig. 30-8. This chart relates the type and amount of training available to the type and level of employment in the world of work.

long. Ask a friend or relative to be honest with you about annoying habits you might have.

To help you be successful on the job, try to build a good relationship with your supervisor. There are many ways to do this. Here are a few:

- Make your supervisor look good.
- Do not take a problem to someone higher in the management chain without your supervisor's knowledge.
- Do not fall into a "buddy-buddy" relationship with your boss.
- Be honest. Also, do not try to bluff your way around a question you cannot answer.
- Accept responsibility for your mistakes. Do not blame others.

There are a number of other factors that will contribute to your being a success on the job. It is important that you maintain good health. Eat right and get enough sleep. Come to work well rested and prepared to meet the challenges of the day. Avoid absenteeism and tardiness. Exercise self-control. Follow company standards and policies. Avoid unethical practices and keep your personal standards high. Be a good producer–maintain high productivity on the job and do quality work.

THE INDIVIDUAL AS A CONSUMER

As consumers, each individual influences manufacturing, Fig. 30-9. Manufacturing companies react to consumer demands. They make products that are needed or wanted.

As you select products, you should keep several factors in mind. One is need. Each customer should ask, "Do I really need this product, or is it a passing fancy?" Another is value. A product should be worth what it costs. Closely related to this is price. First, can you afford the product? Second, is it competitively priced? Shop around to be sure you are getting the best price.

Other factors to consider before making a purchase are:

- Function–"Will the product do what I want or expect it to do?"
- Appearance–"Do I like the looks of the product?"
- Operation–"How hard is it to use?"
- Durability–"How long will it last? How hard or expensive would it be to maintain or repair?"

People should be concerned about the environment. Each customer should ask if the product can be recycled or disposed of safely. The best products for future generations will be those which can be recycled. They can become the raw material of new products.

OTHER IMPACTS ON EVERYDAY LIFE

One underlying theme of this chapter is that studying manufacturing is helpful. It has provided you with valuable information that can be used in everyday situations. For example, through studying unions, you have learned how to set up an agenda and run a meeting using proper parliamentary procedure. You have learned that a meeting should have a purpose, be short and to the point, and be operated under a set of rules. Through the study of manufacturing you have also been learning about:

- Managing your activities.
- Financial affairs.
- Communications skills.

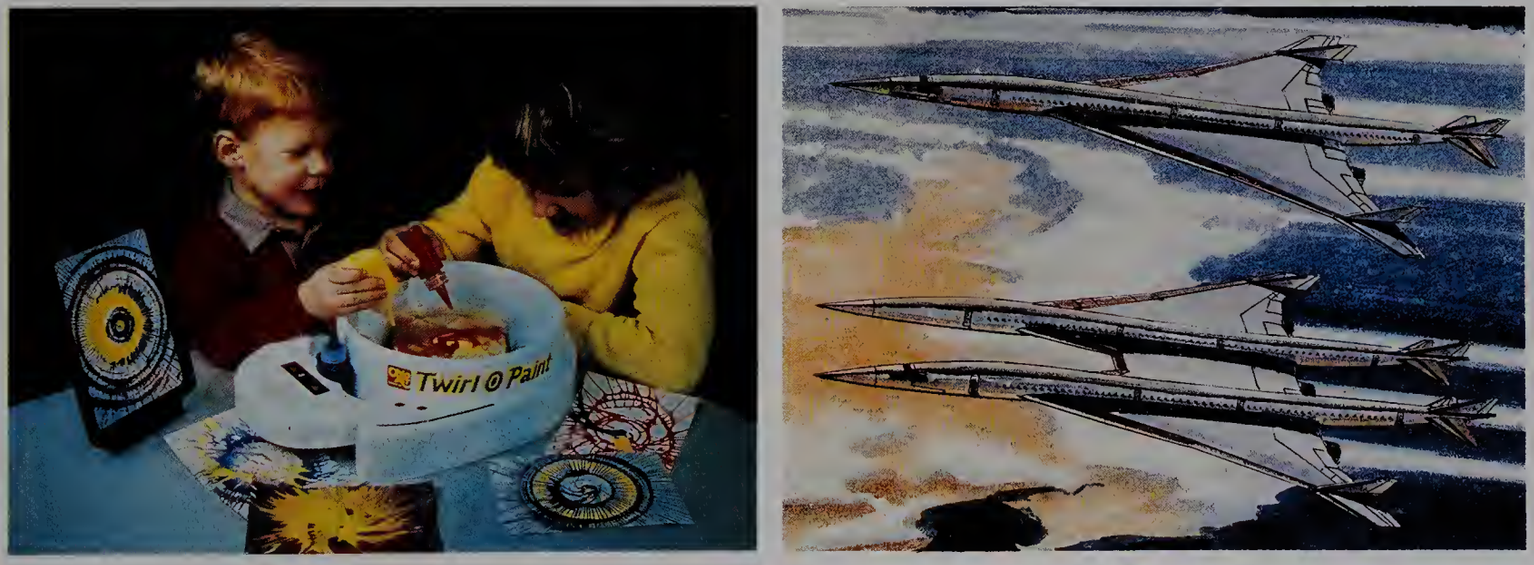


Fig. 30-9. Manufacturing companies produce a spectrum of products ranging from relatively simple (left) to futuristic and complex (right). (Ohio Art Co., NASA)

MANAGING YOUR ACTIVITIES

You have learned about management activities as you have studied manufacturing. You have learned that among the many things managers do are setting goals, determining courses of action, and establishing priorities. You will do the same thing as you approach a job. Often, you will do this subconsciously. In any event, if you approach your activities as a manager would, you will find them easier to complete. You will also be contributing to your personal satisfaction and success.

Furthermore, a lot of *stress* is caused by trying to reach unclear goals through poorly defined routes. Properly managing your activities will be less stressful for you. You will feel less pressured because you will know where you are going and how you plan to get there.

FINANCIAL AFFAIRS

In your study of manufacturing, you have covered the area of financial affairs. What you have learned about general ledgers, credits, and debits can be applied to your personal life. The knowledge you have acquired will aid you in maintaining a personal budget and a checking account.

Let us look at a checking account, Fig. 30-10. You deposit money into it periodically. These are *credits* or *deposits*. Then, you write checks to buy things and pay bills. These are *debits*. Each time you deposit money, the amount is added to the account balance. Each check is subtracted from the balance. Keep track of your balance so that you will know how much money is available to spend.

By studying how companies raise money, you have indirectly learned about borrowing money. Companies use debt financing to obtain operating capital. They sell bonds or obtain bank loans. Likewise, you could also obtain a loan. You would follow the same basic procedure that a company does. That is:

1. Determine how much money is needed.
2. List personal assets (value of property, bank accounts, etc.)
3. Determine the amount of money available each month to repay the loan.
4. Select a bank or other financial institution (savings bank, loan company, insurance company, etc.) to approach for the loan.
5. Complete the loan application.
6. Receive the money.
7. Pay back the loan in installments over a period of years.

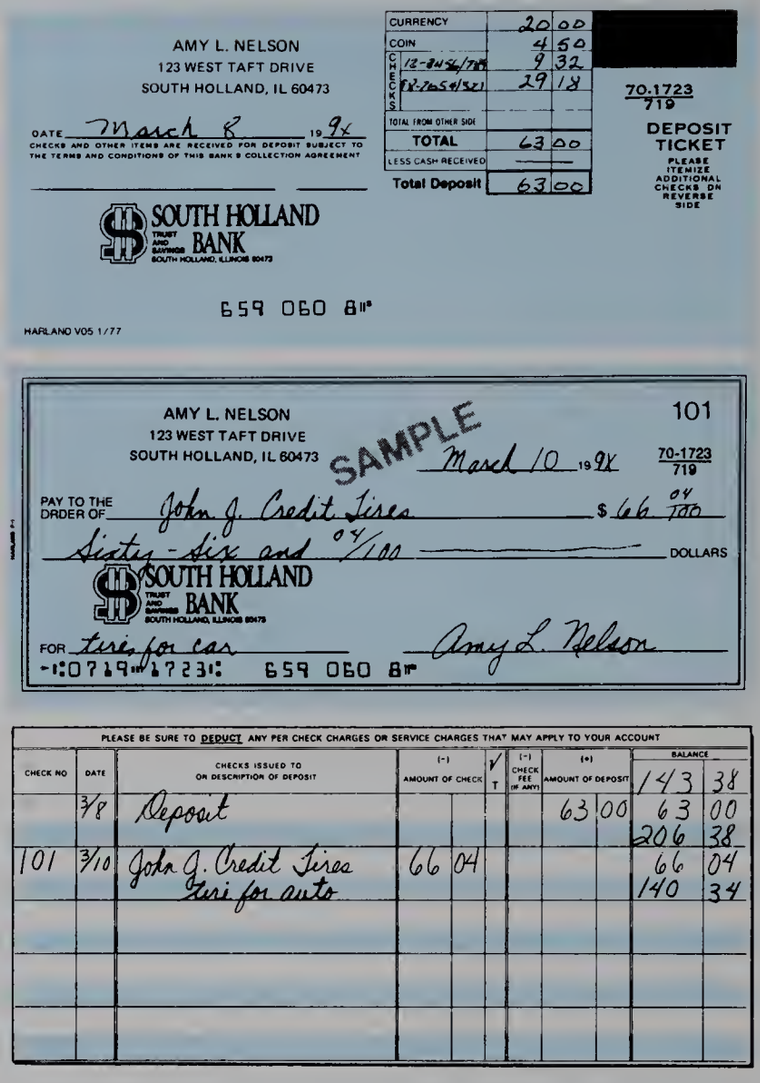


Fig. 30-10. Keeping a checking account means filling out deposit slips (top), writing checks (middle), and keeping track of your account balance (bottom).

Remember that the loan company charges interest for the loan. This means you will be paying back more money than you borrowed.

COMMUNICATIONS SKILLS

Finally, throughout your study of manufacturing, you have had to develop reports, make presentations, design advertisements, and maintain records. You have been developing communications and other skills. Take a closer look. In doing these assignments, you have had to:

- Determine what information an audience needs.
- Gather data to develop a message or a report.
- Organize material using an outline.
- Prepare and edit a written report.
- Prepare graphics and merge them into the report.
- Present a message or a report to an audience.

Perhaps you have not been aware, but you have been acquiring some basic skills that will be of benefit to you throughout your life.

SUMMARY

Knowledge gained through learning about manufacturing can impact a person's life. Leadership opportunities are present in manufacturing and most aspects of life. The best approach to leadership is similar to a participatory management. Manufacturing provides many opportunities for employment. However, a thorough study of personal desires should be conducted in order to determine the right career path to follow.

Study of manufacturing can be related to the individual in other ways. Consumers will determine the products a company makes. Before buying, a consumer should consider whether or not the product fits certain criteria.

Finally, through the study of manufacturing, you have learned of matters relating to successful management, financial affairs, and communications. These matters can be applied to everyday life. From them, you have learned about effectively managing the activities that you do, keeping checking accounts, obtaining loans, and preparing and presenting reports.

KEY WORDS

leadership
synergism

TEST YOUR KNOWLEDGE

(Please do not write in this text. Place your answers on a separate sheet.)

1. A key to good _____ is having the ability to inspire all kinds of people to work together.
2. True or False? Effective leadership is accomplished through giving orders, directing people, and demanding results.
3. Effective leaders have a:
   a. "Team" attitude.
   b. Shared vision.
   c. Plan of action.
   d. All of the above.
4. True or False? Effective team members do not express opinions when they may cause friction in a group.
5. True or False? Working for a living can be rewarding.
6. True or False? Human relations skills are not so important to machine operators because they work with machines all day.
7. What are five general things to consider that will help you choose the right job for you?
8. Indicate which of the following statements is most correct.
   a. Buy a product right away as long as you need it and can afford it.
   b. One way of getting the best price on a product is to shop around.
   c. The consumer has little effect on determining what products a company makes.
   d. None of the above.
9. Lessons learned by studying manufacturing can be applied to everyday life in areas of:
   a. Managing activities.
   b. Financial affairs.
   c. Communications skills.
   d. All of the above.
10. A lot of _____ is caused by trying to reach unclear goals through poorly defined routes.
11. True or False? When you borrow money from a lending institution, the amount of money you pay back is equal to the amount you borrow.
12. What basic skills have you acquired in studying manufacturing? Explain how they will be of value to you.

APPLYING YOUR KNOWLEDGE

1. On a chart similar to that of Fig. 30-A, list what you feel are characteristics of a good leader. Then, for each characteristic, list three state or national figures that possess the quality.
2. Explain synergism in terms of a choir or a football team.
3. Design a bulletin board display that would communicate the attributes of a good leader.

Leadership characteristic	State or national figure possessing this quality
1.	1. 2. 3.
2.	1. 2. 3.
3.	1. 2. 3.
4.	1. 2. 3.
etc.	1. 2. 3.

Fig. 30-A. A suggested chart is shown.

4. Prepare an agenda for a meeting. List steps you would use in conducting the meeting by parliamentary procedure.
5. Select five manufacturing jobs you know about.
   a. Develop a chart like that in Fig. 30-B.
   b. Rate each job in terms of its requirements for working with people, data, things (machines and materials). Use a scale of 1 to 5 (with five being the highest score) to do the rating.
6. Select a job you might be interested in having. Analyze it in terms of its market demand, job demands, appeal to your personal traits, interest, and abilities, educational requirement, and the life-style it would afford.

MANUFACTURING JOB	RATING		
	PEOPLE	DATA	THINGS

Fig. 30-B. A suggested table is shown.

Technical Terms

A

Abrasive cleaning: rubbing a surface with sandpaper or a similar material to smooth it and remove grease or other contaminants.

Abrasive machining: a process that uses an abrasive, in wheel or sheet form, to remove material from the workpiece.

Accounting: the process of maintaining financial records.

Accounts payable: money owed by a company to its suppliers (for material) and its employees (for labor).

Accounts receivable: money owed to the company by customers who have purchased products or services.

Acoustical properties: characteristics of a material that determine how it will react to sound waves.

Acoustical reflectivity: a measure of how well or poorly sound waves bounce off a material.

Acoustical transmission: a measure of a material's ability to transmit sound waves.

Actuating: assigning tasks to specific employees and encouraging them to complete the assigned work.

Adaptive control: a system of automated machine control that adjusts tool feed rates to match changes in operating conditions.

Adhesive bonds: a means of joining materials that makes use of the stickiness or tackiness of the bonding substance.

Administrative budgets: estimates of costs for such activities as industrial relations, research and development, and financial affairs.

Advertising: a marketing function aimed at informing customers and persuading them to buy a product.

Advertising agency: a specialized service company that has experience and talent in developing effective advertising materials.

AFL-CIO: the American Federation of Labor/Congress of Industrial Organizations, the only major labor federation in the United States.

Agency shop: a system under which nonunion workers pay union dues and receive all benefits gained by the union, but do not actually have to be union members.

Alloy: a combination of two or more metals or a metal and another inorganic material.

Amorphous structure: an internal arrangement of atoms in a material that does not follow any specific pattern.

Annealing: a process that softens or removes stress from a material.

Annual report: a complete description of a company's financial activities during the preceding year; usually accompanied by other information about the company and its products.

Anodizing: a method of protecting the surface of a metal by means of an electrolytic treatment that causes it to oxidize.

Applied research: investigations aimed at getting specific results; applied research is aimed at solving problems or developing products.

Apprenticeship training: a lengthy process, involving both classroom training and work experience, for highly skilled positions.

Arbitrator: in a labor dispute, a person who acts as a judge and rules in favor of either the company or the union.

Arc welding: a means of bonding metal, using heat developed by an electric arc to melt and fuse the materials.

Articles of incorporation: the application for a corporate charter, containing information on the activities of the proposed corporation and the names of persons involved in it.

Artificial intelligence (AI): computer-based systems that have the ability to learn from information gathered through sensory inputs.

Assembling: a manufacturing process in which the final product is put together from separate parts.

Assembly drawings: engineering drawings that provide information to show assemblers how parts of a product fit together.

Assets: items of value owned by a company.

Atom: the basic unit in the study of the microstructure of materials.

Atomic closeness: in cohesive bonding, atoms of each part must have the same atomic closeness (be as close together) *across* the joint as they do within the materials themselves.

Automation: replacement of human control for a machine, process, or system, with control by mechanical or electronic devices.

B

Balance sheet: a financial document that gives a picture of the company's financial situation on a specific date.

Bankruptcy: an involuntary dissolution of a company, ordered by a court.

Bargain: to negotiate on behalf of a union or company.

Basic research: seeking after knowledge without being concerned about a specific product or process as a result.

Bending forces: used to form sheet metal, tubing, and bar stock into new shapes.

Bid: a price from a vendor that will remain in effect for a stated period of time.

Biennially: occurring every other year.

Bill of materials: a list of all the parts and hardware items needed to make one product.

Biotechnology: the use of technological systems to grow genetic resources or employ living organisms to reach specific goals (such as the use of enzymes to clean up oil spills).

Blow molding: a process that uses air pressure to form hollow glass or plastic objects.

Board of directors: a group of persons, from both inside and outside the company, who develop general policies for the business.

Bonding: an attractive force that holds atoms and ions together.

Bonds: certificates of indebtedness issued by a corporation as a means of borrowing money.

Branched layout: a form of plant layout used for assembly operations. Subassemblies are produced on branches, then fed to the main stem for use in putting together the final product.

Brand name: a name used to identify a product and differentiate it from competing products.

Brazing: a method of joining metals that involves heating them and melting a filler material that will act as an adhesive.

Break-even chart: a graphic representation of income and expenses, showing the point at which sales income for a product will meet all the expenses involved in producing it.

Brittleness: a measure of a material's lack of resistance to force. A brittle material fractures easily.

Brushing: a cleaning method that uses a wire-bristled brush to dislodge and remove contaminants and dirt from a surface.

Budget: an estimate of revenues and expenses.

Business plan: a document or program that describes all aspects of a projected new business.

Bylaws: the general rules of an organization, such as a corporation.

C

Capital resources: a company's plant and equipment.

Capital: the tools and machines that are necessary inputs for all technological systems.

Carbon steels: the most common forms of steel, widely used in manufacturing products such as automobiles, machinery, and appliances.

Cash flow: the money handling activities of a company, consisting of income and expenses.

Casting: a process in which a liquid material is poured into a cavity in a mold, where it solidifies.

Caustic cleaning: a surface preparation methods employing strongly alkaline solutions.

Cavity: a shaped hole inside a mold.

Central processing unit (CPU): an integrated circuit that controls and sequences operations of a computer.

Centrifugal casting: a forming process in which molten metal is placed in a spinning mold to form a hollow product.

Ceramic materials: crystalline materials, mostly inorganic, that are often very hard but easily shattered. Glass is a good example.

Certificate of representation: recognition awarded by the National Labor Relations Board, allowing a union to serves as the bargaining agent for a group of workers.

Charter: a certificate, issued by a state, that gives a corporation legal standing and permits it to operate.

Chemical conditioning: a method of changing the internal properties of a material through chemical reaction.

Chemical machining: a process that uses powerful chemicals to etch (eat away) excess material from the workpiece.

Chemical preparation: use of solvents or steam and detergents to remove grease and other contaminants from a surface prior to finishing.

Chemical properties: characteristics of a material that determine how it will react chemically.

Chromate conversion coating: a finishing process that provides a clear coating on cadmium- and zinc-plated steel parts.

Circular saw: a cutting device with a rotating blade. The workpiece may be fed into the blade, or the blade moved across the work.

Clamping devices: machines that hold or support the workpiece or a cutting element.

Cohesive bonds: a means of joining materials that uses the same forces that hold the molecules of the substance together.

Cold bonding: a means of joining ductile metals, such as aluminum or copper, by applying very high pressure in a small area.

Cold forming: forming of material at temperatures below the recrystallization point.

Collective bargaining: a negotiating process aimed at bringing about an agreement between the company and its workers (as a group)

Collective bargaining: the process in which a union representing the workers meets with management to work out a contract.

Committeeman: another term for a union steward.

Communication technology: the use of technological means to convey information and ideas.

Company or idea advertising: print media ads or radio/TV commercials designed to promote a company's image or a specific idea.

Composites: a combination of two or more materials with properties the materials do not have by themselves.

Compound: a material consisting of atoms of two or more different elements in definite proportions.

Compounded: mixed together; used to describe blending of liquid or finely divided solid materials in preparation for molding or casting.

Comprehensives: finished advertisements, ready for reproduction. Also referred to as *mechanicals* or *camera-ready art*.

Compression strength: the ability to resist squeezing forces.

Computer: a device that includes a central processing unit, input/output unit, and a memory.

Computer numerical control (CNC): control of an individual machine by a computer that replaced an NC paper tape reader.

Computer-aided design (CAD): a computer-based system used to create, modify, and communicate a plan or product design.

Computer-aided manufacture (CAM): a system that uses computer technology in the management and control of manufacturing operations.

Computer-aided process planning (CAPP): an integrated system that coordinates all tasks associated with the manufacturing process.

Computer-integrated manufacture (CIM): an approach in which all steps in producing a product, from recognition of need for it through manufacture and marketing, are integrated into a single, dynamic computer-controlled system.

Conciliator: a person whose sole duty in a negotiation is to try to clear up problems and help the parties reach agreement.

Conditioning: a process in which the internal structure of a material is changed to alter its properties.

Conductors: materials that permit a ready flow of electrical current.

Constitution: the document governing operation of a union or other organization.

Construction technology: the use of technological systems to build houses, stores, industrial plants, bridges, and other structures.

Consumer products: those made for, and sold to, the general public.

Continuous manufacturing: a system designed to turn out a large quantity of like products.

Contouring machines: equipment that can move a tool, under numerical control, in any or all machine axes at the same time.

Control: the financial affairs area of a company that maintains financial records and develops and monitors budgets.

Controlling: comparing actual results to goals and the plans developed for reaching them.

Convention: a periodic national meeting held to develop union governing policies.

Conversion finish: a process that chemically alters the surface of a material into a protective layer.

Copy platform: the theme or basic objectives of an advertising campaign.

Copy: the written portion of an advertisement, whether for use in print or as a radio/TV commercial.

Corporation: a company that is a legal "being" in one state. Investors purchases shares of stock, which represent ownership of a fraction of the corporation. The people who manage the corporation may or may not be shareholders.

Cost accounting: a system of charging expenses to specific categories.

Counterboring: a machining operation that produces two straight, round holes on the same axis in a workpiece. The upper hole is larger, to allow the head of a fastener to be set below the surface.

Countersinking: a machining operation that is similar to counterboring, but with a beveled upper hole. Countersinking is done to sink the head of a flathead fastener below the surface.

Court order: a legal action used to dissolve a business by forcing it into bankruptcy.

Covalent bonding: sharing of electrons by elements to form a stable structure.

Creditors: individuals, companies, and financial institutions to whom the company owes money.

Credits: in accounting terms, money coming into a company.

Crystalline structures: those composed of boxlike units, called crystals, arranged in a lattice form.

Custom manufacturing: a system in which a small number of products is made to a customer's order.

Cutting elements: tools or blades that are made of material harder than the material to be cut.

Cutting motion: relative movement between the workpiece and the tool that causes material to be removed.

D

Daily production reports: an important source of manufacturing data that allows comparison of actual production to scheduled activity.

Debits: in accounting terms, money being paid out by a company.

Debt financing: raising money for a company by borrowing from a bank or selling bonds.

Deferred taxes: taxes due on money earned by a company that have been legally postponed until a later date.

Delegates: persons elected by fellow union members to represent them at a national convention.

Density: a measure of the mass per unit volume of a material. Density is usually expressed in pounds per cubic foot or kilograms per cubic meter.

Depth of cut: the amount of material that a tool separates from the workpiece in one stroke or revolution.

Descriptive knowledge: the area of human knowledge that includes language and mathematics. It is the basis for communication.

Detail design: activities that give a product its final appearance and functional characteristics.

Detail drawings: engineering drawings that provide information needed to produce a particular part.

Development: the process of turning applied research results into marketable products or workable processes.

Die casting: a forming process in which melted metal is forced into a steel mold, or *die*.

Dies: shaping devices which material is squeezed between or formed over to achieve a new shape.

Dimension: the desired size (length, width, etc.), as shown on an engineering drawing.

Dip coating: a finish obtained by submerging the material in a container of coating material.

Dipping: a finishing method in which the material is dipped into a vat of molten metal.

Direct labor: supervisory and processing labor that is directly involved in producing the product.

Direct materials: the materials that actually become part of a product.

Direct numerical control (DNC): a system using a computer to communicate directions to each machine tool, as needed, to perform a sequence of operations.

Dispatching: the process of issuing production orders to start the manufacturing process.

Dispersed or filler composites: materials consisting of a skeleton filled with another material. Fiberglass is such a composite.

Dissolution: the process of closing down a business.

Dissolved: broken up into tiny particles and mixed with a liquid.

Distribution: the system needed to get products from the manufacturer to the consumer.

Dividend: share of profits that is paid to a company's stockholders.

Draft: angled sides on a pattern that allow it to be removed from a mold.

Draw bench: a machine that forms wires and other shapes by pulling material through a die.

Drawing: a forming process that involves stretching metal into the desired shape.

Drawing forces: forces that pull and stretch material into the desired shape.

Drilling: a machining operation that produces a straight, round hole in a workpiece.

Drop forging: shaping of material between two dies using the force of a falling (drop) hammer.

Drying: heating a material to reduce its moisture content.

Ductility: a property that allows a material to undergo plastic deformation without rupturing.

Due date: the date when an invoice must be paid. Usually, 30 days from the invoice date.

E

Elasticity: a material's ability to return to its original shape after being deformed by an applied force.

Elastomers: natural or synthetic polymers that quickly return to their natural size after being stretched.

Electrical discharge grinding (EDG): a process that uses a spark as a cutting tool between a rotating disc and the workpiece.

Electrical discharge machining (EDM): a process that uses a spark (electrical discharge) to erode a small chip from the workpiece. EDM is widely used to make cavities for forging and stamping dies.

Electrical discharge sawing (EDS): a process that uses a spark as a cutting tool between a moving knife edge band and the workpiece.

Electrical discharge wire cutting (EDWC): a process that uses a spark as a cutting tool between a taut traveling wire and the workpiece.

Electrical properties: characteristics of a material that determine how well or poorly it will carry electrical current.

Electromagnetic forming: a process used to change the shape of a material through use of a very strong magnetic field.

Electroplating: the use of an electric current to deposit a thin, uniform metal layer on the surface of a base material.

Elements: the "pure" substances that are the basic building blocks for all materials on earth.

Employee relations: the department responsible for employee hiring, training, and related activities.

Enamel: a varnish to which a pigment has been added to produce a colored coating.

End effectors: tools at the end of a robot's arm, used to perform work.

Energy: the capacity for doing work. Energy is a necessary input in all technological systems.

Engineering change order: a document describing a change in a product and how it is to be made.

Engineering data: information related to the product and how it is manufactured.

Engineering drawings: drawings that show the size and shape of parts and products.

Engineering materials: solid materials that will hold their shapes without outside support.

Engineering testing: careful checking of product quality and function.

Enterprise: a business; a unit of economic organization or activity.

Entrepreneurs: persons who organize, manage, and assume the risks of a business enterprise.

Equity financing: raising money for a company by selling shares of ownership.

Evolving technologies: areas of technology that are undergoing continuing change.

Expediting: the process of checking to determine whether production is on schedule.

Expel: to take away membership in an organization.

Expendable molds: inexpensive molds that are destroyed in removing the casting.

Expense: money that a company spends to purchase goods and services.

Explosive forming: a forming process that uses explosive charges to force material against a die.

External storage devices: disks or tapes used to store data outside a computer.

Extracting: the process of removing a finished part from a mold.

Extractive technology: the use of technological systems to recover natural resources from the earth and seas.

Extrusion: a process in which material is pushed through a hole in a die.

F

Face turning: a machining process in which the cutter moves across the face, or end, of a rotating workpiece.

Factories: special buildings where people use machines to manufacture products.

Factory burden (overhead) budget: a means of assigning portions of plant costs, such as utilities and maintenance, to each product produced.

Federations: organizations made up of groups that have banded together for a common purpose.

Feed motion: in machining, the movement that brings new material in contact with the cutting element.

Feedback: information that a system uses to control itself. By measuring an output, the system gains information needed to take corrective action.

Ferrous metals: alloys with varying percentages of iron and carbon.

Fiber composites: materials consisting of fibers that are bonded together.

Final assembly: the process of combining subassemblies to form the completed product.

Finance: the process of planning to acquire money for the company and determining the use of available funds.

Financial affairs: the area of managerial technology concerned with raising money and maintaining financial records.

Financial budget: a document prepared to predict income and expenses for a specific period.

Financial data: an estimate of manufacturing costs, selling price, and expected profit from a new product.

Finishing: the process of giving a product a protective or decorative coating or surface treatment.

Fired: term used to describe someone whose employment has been terminated for violating company rules or other cause.

Firing: heating a ceramic material to fuse clay into a hard, rigid material.

Five-step employment process: a system used by many companies to find and hire new workers.

Fixed costs: those costs, such as factory overhead, that remain constant even if production levels change.

Fixed path systems: material handling systems that use specific routes from point to point. Conveyors and piping are examples of fixed path systems.

Fixed sequence robot: a simple robot that performs a simple sequence of events, over and over.

Flame cutting: a process in which a mixtures of gases is burned to melt a path between the workpiece and the excess material.

Flexible manufacturing: a system of computer controlled manufacturing that permits production of small quantities without increasing costs.

Flow bonding: a method of joining materials that uses a filler metal that melts onto a heated base metal. When cool, the filler metal acts as an adhesive.

Flow coating: a process that floods the surface with a finishing material. The excess is allowed to drip off the material.

Flow diagram: a graphic method of monitoring movement of parts through the plant.

Flow process chart: a graphic means of showing all the steps and processes a single part goes through as it is manufactured.

Forging: shaping of heated metal by forcefully closing die halves on it, using either a drop hammer or a hydraulic ram.

Form utility: changing the form of a material to make it more useful.

Forming: a process that changes the shape and size of a material by a combination of force and a shaped form (such as a die or forming rolls).

Fracture point: in forming, the point at which force is strong enough to break the material.

Free enterprise system: an economic system in which privately owned, for-profit enterprises compete for business.

Fringe benefits: things a company pays for beyond basic wage or salary, such as health and medical insurance programs.

Fusion bonding: a type of bonding that melts the edges of the materials being joined so that they can flow together.

Futurist: a person who tries to predict possible future conditions on the basis of historical perspective and current trends.

G

Gas welding: a means of bonding metal, using the heat of an oxygen/acetylene flame to melt and fuse the materials.

General expense budgets: estimates of costs for company expenses that are not directly related to producing products.

General ledger: a central record of all the financial transactions made by a company.

General overhead: corporate costs for product development, marketing, and administrative activities.

Goodwill: the value of the company's name and reputation, as well as trademarks and patents it owns.

Green sand casting molds: a type of expendable mold, formed from a special sand and used for metal casting.

Grievance: a formal complaint by a worker about a manager's violation of the union contract.

Grievance procedure: a means of settling disputes between workers and the company, as outlined in the union contract.

H

Hammer: a machine that delivers a sharp blow with a movable upper head to forge metal.

Hard copy devices: equipment that can be connected to a computer and used to obtain a paper or film copy of information processed by the computer.

Hardening: a process used to make a material more resistant to denting, scratching, or other damage.

Hardness: the ability of a material to resist scratching or denting.

Hardware: the physical components of a computer system.

Hardwoods: woods from broad-leafed deciduous trees, such as oak.

Heat-treating: a general term for thermal conditioning processes.

High alloy steels: special steels alloyed with molybdenum, nickel, tungsten, or other elements; tool steel is an example.

Horizontal milling machine: a machine that cuts a flat surface on a part held in a vise.

Hot forming: forming of material that is heated above the recrystallization point.

Hot melts: a type of finish that is made liquid by heating, then forms a coating as it cools to a solid state.

Human resource development (HRD): another name for employee relations.

Humanities: the study of areas of philosophy that relate to human concerns. Studying the humanities helps people develop personal priorities

I

Incentive pay: payments made for completing work above set standards.

Income: the money a company receives, primarily from sales of products or services.

Income statement: a financial document that gives a picture of the company's financial situation over a period of time.

Indirect labor: labor that serves and supports the production activities.

Indirect materials: the supplies and other materials used in manufacturing the product.

Induction training: basic information on the company and its policies, usually required for all new workers.

Industrial materials: materials ready for secondary processing into manufactured products. Also known as *standard stock*.

Industrial products: tools, machinery, supplies, and other goods sold to industrial firms, rather than consumers.

Industrial relations: the area of managerial technology concerned with the human aspects of the manufacturing enterprise, such as personnel and labor relations.

Industrial robot: a programmable manipulator capable of a variety of functions in a manufacturing setting.

Industrial sales: the basic market for the manufacturer, who sells products to wholesale and retail companies.

Industrial system: one designed to transform resources into outputs for a large number of people.

Industrialized society: one in which people use machines to manufacture large quantities of products from materials.

Industry: a series of enterprises that make similar products, such as the *steel industry*.

Injection molding: a process similar to die casting, but usually used for plastics rather than metals.

Inorganic coatings: finishing products derived from mineral-based materials.

Inorganic materials: those that are nonliving; ores and earth elements.

Input devices: external components, such as a keyboard or a digitizing tablet, that are used to enter data and directions into a computer.

Input/output unit: component of the computer that communicates with external input and output devices.

Inputs: those items put into a system to be processed and become outputs that achieve the system goal.

Inspection: examination of products, as they are being made or after manufacturing, to make sure that they meet quality standards.

Inspection orders: forms used to schedule quality control checks.

Inspection tag: a card attached to a defective part, telling what is wrong and what should be done with it.

Interference fits: a means of assembly that makes use of mechanical force to hold parts together.

Intermittent manufacturing: a system in which parts are produced in groups or *job lots*, in contrast to continuous manufacturing.

International union: a union with locals in both the United States and Canada.

Intrepreneurs: employees of an existing business who are encouraged to apply entrepreneurial skills within that business.

Inventory: the value of materials, work-in-process, and finished goods owned by a company.

Inventory turn: the time it takes for a store's supply of a product to "sell out" and be reordered.

Invoice: a bill from a vendor for payment due on materials sold to a company.

Ion: an atom with a positive or negative charge.

Ionic bonding: the bond formed between atoms by the attraction of opposite electrical charges.

J

Job analysis: the first step of a wage and salary study, involving an assessment of the job and the skills and knowledge required.

Job description: a written document describing the duties and needed skills involved in a specific position.

Job pricing: the process of attaching a wage rate to each job or job classification.

Job rating: the grouping of jobs (by skills required and other considerations) to establish rates of pay.

Job security: the permanence and stability of employment with a company.

Joint: the point where two parts of an assembly come together and are fastened.

Just-in-time (JIT) manufacturing: a system that reduces inventories of raw materials and product components to the absolute minimum. Materials and parts are scheduled to arrive at the production line just when needed for use.

L

Labor agreement: a contract between a union and a company that sets wage rates, job conditions, and other matters affecting workers.

Labor budget: an estimate amount of labor needed for production, allowing a forecast of labor costs.

Labor relations: activities involved in solving problems that arise between workers and management.

Labor union: an organization that gives workers a united voice when dealing with management.

Lacquer: a solvent-based material that dries to a clear protective coating through evaporation.

Laid off: term used to describe workers whose services are not required, temporarily or permanently, due to lack of business.

Laminate composites: materials composed of layers of wood.

Laser beam machining (LBM): a cutting method that uses a beam of focused light to melt a path in the material and separate the excess from the workpiece.

Layout: the suggested arrangement of copy and illustrations for a print advertisement. A layout is submitted by an advertising agency for the company's approval.

Lead time: the time that must be allowed between a decision to build a product and actually building it.

Leadership: the ability to inspire others to work together.

Liabilities: the debts owed by a company.

Light reflection: a measurement of how well or poorly light waves bounce off a material.

Light transmission: a measurement of how well or poorly light waves pass through a material.

Line organization: a form of business organization in which each position reports only to the manager immediately above it.

Line production routing sheet: a form that summarizes basic information about each production operation.

Linear: movement in a straight line; often used in reference to a machining operation.

Loan: money borrowed by a company from a bank or other lender for a specific term at a stated rate of interest.

Local union: a labor union organized at the single plant or community level.

Long-term debt: money owed to creditors that is to be repaid over a period longer than one year.

M

Machining: a process that changes the size or shape of a workpiece by removing excess material as chips or shavings.

Machining centers: complex, computer-controlled manufacturing machines that can perform a number of operations, in sequence, on a part or product.

Machining operations: separating processes in which excess material is removed in the form of chips.

Macrostructure: the way in which different substances unite to form complex materials called composites.

Magnetic conductivity: the ability of a material to conduct magnetic lines of force

Magnetic permeability: a measurement of a material's ability to become magnetized.

Magnetic properties: characteristics of a material that govern its reaction to a magnetic field.

Management: the group of persons who supervise operation of a business.

Management information systems: computerized systems of information processing that help a company achieve peak operational efficiency.

Management processes: processes that are used to assure the efficient and appropriate use of resources.

Managerial technology: the use of systems and procedures to insure that transformation actions are efficient and appropriate.

Managers: company officials who make hiring, firing, and discipline decisions.

Manufacturing: the process of changing resources into products.

Manufacturing cell: a small group of machines connected by a material handling system. Often, the individual elements of the cell are computer-controlled to increase flexibility and efficiency.

Manufacturing engineering: an activity devoted to making the physical layout of the plant, the manufacturing processes, and the production equipment as efficient as possible.

Manufacturing resource planning II (MRP II): a complex, computer-controlled system that can be

used to control most aspects of production from scheduling to recording output.

Manufacturing technology: the use of technological systems to transform materials into products at a central location (manufacturing plant).

Manufacturing (variable) costs: those costs, such as labor and material expenses, that vary as production increases or decreases.

Market approach: a means of selecting products to manufacture based on the needs and desires of customers.

Market information: a component of market research that focuses on identifying the segment of the market most likely to purchase a product.

Market profile: a description of the type of customer a company is trying to reach with a new product.

Market research: the process of gathering and analyzing information about customers' desires, competing products, and sales results.

Marketing: the area of managerial technology concerned with moving a product from the manufacturer to the customer by means of advertising and selling activities.

Marketing budgets: estimates of costs involved in promoting, selling, and distributing the company's products.

Marketing data: information on potential customers and the competitive environment.

Marketing mix: a term used to describe the various activities carried out under a marketing plan.

Marketing system information: a component of market research that focuses on the effectiveness of advertising, packaging, sales approaches, and channels of distribution.

Master budget: a summary of all the specialized estimates (such as sales, production, and general expense budgets) prepared for different company activities. It provides an overall picture for top managers.

Mated dies: a set of dies with a raised shape on one die and a matching cavity in the other. Material is squeezed between the two to take the desired shape.

Material handling: the act of moving material from place to place in a factory.

Material handling engineering: the design and installation of systems to move material from place to place in a plant.

Material processing technology: another way of describing *transformation technology*.

Materials budget: lists of needed production materials and supplies, used as a basis for estimating costs.

Materials requirement planning (MRP): a system that allows schedulers to place priorities on materials and products to be produced.

Maximum profitability point: the price at which a company makes the greatest possible profit from a product.

Mechanical conditioning: changes to the internal structure of a material as a result of manufacturing processes. The changes are not always suitable; the material may have to be conditioned further to restore it to the desired state.

Mechanical fastening: a method of holding parts together temporarily or permanently with mechanical fasteners or force.

Mechanical preparation: use of an abrasive or similar material to prepare a surface for finishing.

Mechanical properties: characteristics that govern how the material will react to a force or load.

Media cleaning: surface preparation methods which propel, vibrate, or tumble some form of abrasive against the surface of the material to be cleaned.

Mediator: a person who can recommend a solution to labor and management negotiators. They are not required to accept it.

Melted: heated until a liquid or semi-liquid state is attained.

Memory: component inside a computer used by the CPU to store data.

Metal planer: a machine that removes excess material by moving the workpiece back and forth against a stationary cutting tool.

Metal shaper: a machine that removes excess material by moving the cutting tool back and forth over a stationary workpiece.

Metal spinning: a forming method in which a rotating disc of soft metal is deformed by pressure of a tool.

Metallic bonding: a combination of attracting and repelling forces that produces a very rigid structure.

Metallic coatings: finishes that consist of metal particles forming a surface layer on the base material.

Metallic materials: inorganic, crystalline substances with a wide range of physical and mechanical properties.

Metallizing: application of a very thin finish of metal particles by means of spraying or vaporizing in a vacuum chamber.

Methods engineering: the task of determining how a product will be made.

Microstructure: the way molecules and crystals are arranged in a material.

Military products: equipment and supplies sold to armed forces.

Mock-ups: models designed to simulate the appearance of a new product.

Moisture content: the amount of water trapped within a material's structure. It is expressed as a percentage of the dry weight of the material.

Mold: in casting and molding processes, a hollow form used to hold molten material until it solidifies.

Molding: a process similar to casting, in which material solidifies in a hollow mold; usually used when referring to plastics.

Molecular structures: a structure made up of polymeric chains held together with covalent bonds.

Monomer: a chemical compound that can unite with other monomers to form a polymer.

Move orders: forms used to schedule material movement in a plant.

Multiple point tools: an arrangement of two or more single-point tools to form a cutting device.

N

National Labor Relations Act of 1935: law that guarantees workers right to form or join unions and to bargain with an employer.

National union: a countrywide organization made up of local unions.

Natural polymers: those that occur in a usable form in nature, such as wood, wool, or natural (latex) rubber.

Negotiators: union and company representatives who meet to seek compromise on basic issues and work out a labor agreement.

Net income: a company's total income minus its expenses.

Net profit: what remains after subtracting all expenses from total income; also called *net income*.

Net worth: the value of a company's assets minus its liabilities.

Nonengineering materials: gases and liquids that must be confined in a container to hold a particular shape.

Nonferrous metals: metals that do not have iron as their principal ingredient. Copper, aluminum, gold, and silver are all nonferrous metals.

Normalizing: a thermal conditioning process that relieves stress in steel and develops a fine, uniform grain structure.

Numerical control (NC): a method of programming manufacturing machines to be controlled by a code consisting of numbers, letters, or other symbols.

O

On-the-job-training: a method of teaching skills at the workstation, often under the guidance of an experienced worker.

Open die: a simple type of shaping device in which the material is formed between two flat die halves.

Open shop: arrangement under which workers are free to join or not join a union, as they choose.

Operation analysis charts: charts used by engineers to study individual manufacturing operations.

Operation process chart: a combination of all the flow process charts for parts making up a product. This chart shows where the parts come together to form assemblies, and finally, the product itself.

Optical properties: characteristics of a material that determine how it will react to light waves.

Ores: earth or rock from which metal can be commercially extracted.

Organic coatings: finishing products derived from living or once-living sources. Natural gums or resins from trees are widely used.

Organic materials: those whose origins can be traced back to living things.

Organized labor: the general term for workers who have organized into unions.

Organizing: developing a structure to reach goals that have been established.

Orthographic projections: drawings showing a component or product from the front, the side, and (often) the top.

Outputs: the results of a process. Outputs may be desired (such as a product) or undesired (such as pollution).

Oxide conversion: a process that provides a finish that resists corrosion and abrasion.

P

Packaging: the process of designing a package for a product. The term is also used to refer to the package itself.

Paint: a coating that changes from a liquid to a solid by means of a polymerization reaction.

Parliamentary procedures: recognized rules and practices for running any types of meeting.

Participatory management: a system in which workers and managers participate equally in making business decisions.

Particle composites: materials consisting of particles or flakes that are bonded together.

Partnership: a form of business ownership involving two or more persons. Usually, partners will have

equal shares of ownership of the business.

Pattern: a shape, made from wood or other material, that is used to form a mold.

Payment: a transfer of funds, usually in the form of a check, to pay a debt (such as an invoice for material)

Payment terms: a statement on a vendor's invoice telling when payment is expected; sometimes, a prompt payment discount is offered.

Payroll data: information on hours worked by each employee, used to prepare the payroll.

Periodic table of elements: a listing of the chemical elements arranged by their properties and levels of chemical activity.

Permanent fasteners: joining devices designed to remain in place. To be removed, they must be destroyed.

Permanent molds: molds that can be used again and again to cast or mold a part.

Perspective model: a lifelike view of an object that is shown as the eye would see it naturally.

Phosphate conversion coating: a finishing process used as a prepaint coating on steel.

Physical properties: physical characteristics of a material, such as density, size and shape, structure, and surface texture.

Pickling: a cleaning method that uses acid to prepare the surface of a metal.

Pilot run: a small-scale production test for a product, assembly line, or entire plant.

Planning: setting goals and the major course of action to reach them.

Plant layout: in a manufacturing operation, the placement of machines and other equipment to promote the efficient flow of materials and people.

Plaster investment molds: expendable molds formed by pouring plaster around a wax pattern. Once the plaster hardens, heat is applied to melt and remove the wax pattern.

Plasticity: a material's ability to flow into a new shape when pressure is applied.

Plastics: another term for synthetic (human-made) polymers.

Point-to-point (PTP) machines: numerical control machines that position a cutting tool above one point on a workpiece, carry out an operation, then move the tool to the point where the next operation is to be carried out.

Political power: the ability of an organization to gain the attention and cooperation of elected officials because of the large number of voters it represents.

Polymer: an organic material composed of chain-like molecules of repeating units; plastic.

Polymeric materials: organic, noncrystalline substances with long, chain-like molecular structures.

Polymerization: linking together of chain-like molecules of a plastic, changing it from a liquid to a solid.

Porosity: the ability of a material to absorb a liquid or gas.

Preliminary design activities: preparation of renderings, mock-ups, and other methods of refining the appearance and function of a product under development.

Press: a machine that shapes or cuts material by applying steady pressure.

Press fit: a method of fastening that relies on the friction between closely fitting parts to hold them together.

Press forging: shaping of material between two dies using the force of a hydraulic ram.

Pressure bonding: a method of joining materials that uses both heat and pressure.

Prevailing wages: the rates of pay generally established for jobs in a geographic area.

Primary processing: the first step in transforming raw materials into products. Example: Converting trees into lumber at a sawmill.

Private technological system: one designed to meet the needs of an individual.

Processes layout: a manufacturing arrangement in which all equipment that performs the same function is grouped together.

Product advertising: print media ads or radio/TV commercials designed to sell a product, rather than promote a company.

Product developers: people who are responsible for seeking new product ideas compatible with the company that they work for.

Product engineering: a research and development function that involves specifying the characteristics of a product.

Product information: a component of market research that focuses on customers' reactions to existing products and desires for new products.

Product layout: a manufacturing arrangement in which equipment is arranged in the sequence of operations needed to produce the product.

Product profile: a list of the general requirements that a new product must meet.

Product-centered activities: managed areas of activity in manufacturing that directly move a product idea from the designer's mind to the market. These

areas consist of research and development, production, and marketing.

Production: the area of managerial technology concerned with using machines and tools to transform resources into products.

Production approach: a means of selecting products to manufacture based on capabilities of the factory and its equipment.

Production expense budget: an estimate of the material, labor, and overhead costs needed to carry out manufacturing activities.

Production overhead: all production costs that are not direct labor or direct materials.

Production planning and control: an activity devoted to scheduling and coordinating the manufacturing of products.

Production schedule: a plan for making most efficient use of equipment and workers to manufacture products.

Production tooling: special devices that increase the speed, accuracy, and safety of production processes.

Profit: the amount of money left over after all the expenses of a business have been paid.

Profit and loss statement: another name for the document known as an *income statement*; often referred to as a "P & L."

Profit center: a unit chosen for cost accounting. A profit canter may be a single product, a department, an entire plant, or a group of plants.

Profit sharing: a system that allows employees to benefit from efficient operation by sharing in the company's profits.

Prompt payment discount: payment terms allowing a company to take a small discount (usually 2 percent) off the amount of the bill, if it is paid in 10 days.

Properties: traits or qualities that are specific to a material.

Proprietor: the owner of a business.

Prototypes: working models of a new product, intended to test its operation.

Public relations: a program that a company uses to inform people of its contributions to community welfare.

Purchase order: a firm order for materials at a specific price.

Purchasing: the buying of equipment, supplies, and other goods needed to run the company and produce products.

Purchasing system: a method used to purchase materials, following a regular sequence of activities.

Q

Quality circles: teams of managers and workers that meet to determine ways product quality can be improved.

Quality control: the process of ensuring that a product meets specifications and standards.

Quote: a statement by a vendor of the most recent price for an item. The price quoted, however, is subject to change.

R

Rake: an angle that slopes away from the cutting edge of a tool. It reduces the force needed to produce a chip.

Raw materials: some form of material found on earth; natural resources.

Reaming: a machining operation that uses a rotating cutter to shape or enlarge a hole.

Receiving report: a confirmation that the material ordered from a vendor has been received by the buyer.

Reciprocate: move back and forth. Some types of machining are done with a reciprocating motion of either the tool or the workpiece.

Recruitment: the process of attracting potential workers to a company.

Refined sketches: a drawing with a more finished appearance than a rough sketch, used to show how a product will look and work.

Relief angles: bevels provided behind cutting edges to help them penetrate the material and reduce frictional heat.

Research: the systematic search for unknown facts or principles.

Research and development: the area of managerial technology concerned with designing and specifying products.

Resistors: materials through which electrical current will not readily flow; insulators.

Retail sales: products sold to consumers, as contrasted to sales made to wholesale and retail companies.

Retained earnings: the portion of profits that a company uses to expand its operations or to develop new products.

Rolling: a forming process that uses a rotating applied force to change the thickness of a piece of steel or other material. Also, a finishing method in which a coating is applied by a roller.

Rolling machine: a device that changes the thickness of a material by squeezing it between rotating rolls.

Rotate: to turn about a central axis, or revolve. Either the workpiece or the tool rotates in many types of machining operations.

Rough sketches: preliminary drawings made by a designer to show a design idea.

Routing: the process of determining the best path through the manufacturing system for parts and products.

S

Sales: the exchange of products for money.

Sales budget: an estimate of sales for a specific period of time.

Sales call record: a form detailing the contacts made with customers by a salesperson.

Sales income: the money a company receives for its products when they are sold.

Sales order: a form that records the details of each product sale.

Scheduling: the process of determining the timing of each phase of production.

Schematics: systems drawings used to convey information on electrical, hydraulic, pneumatic, or mechanical systems.

Science: the study of the laws and principles that govern the physical universe.

Scrap: reusable surplus material resulting from a manufacturing process.

Seaming: a means of joining sheet metal and similar materials by folding and interlocking the edges.

Secondary processing: the steps in the manufacturing process in which industrial materials are converted to useful products.

Semiconductors: materials that will conduct electricity under certain conditions.

Semipermanent fasteners: devices designed to remain in place, but capable of being removed without being seriously damaged. A wood screw is an example.

Separating: a process that changes the shape or size of materials by cutting or shearing away the excess material.

Severance pay: a special allowance often paid to workers who lose their jobs.

Shaped die: a one-piece die over which material is formed.

Shaped rolls: rotating forming devices with grooves machined into them.

Shaping device: a machine or tool used to determine the final shape of a part or product.

Shear strength: the ability to resist opposing forces that would fracture the material along grain lines.

Shearing: a process that uses force applied to opposed edges to fracture excess material away from the workpiece.

Shearing machines: devices that cut material by fracturing it between opposing tool edges.

Shell molds: molds formed as thin resin and sand shells on heated metal patterns.

Shot peening: a process that sprays tiny steel balls against metal parts. The balls pit the surface of the metal and increase its fatigue-resistance.

Shrink fit: a fastening method in which one part is heated to make it expand. After the parts are assembled, the heated piece cools and shrinks, resulting in a tight fit.

Single point tools: simple tools with only one cutting edge.

Single proprietorship: a business owned by one person. Many small businesses are single proprietorships.

Slip: fine particles of clay suspended in liquid for ease in molding ceramic products.

Slip casting: a process in which a solution of clay particles suspended in water is poured into a mold. The water evaporates, leaving the clay behind. Either solid or hollow objects can be slip cast.

Slush casting: a process in which a thin-walled hollow casting is formed from molten metal or powdered plastic.

Smooth rolls: rotating forming devices used to squeeze material to the desired thickness.

Societal goals: the meeting of the broad needs and wants of human society.

Software: the set of instructions used by a computer. Different software is used for various tasks, such as word processing, filing, operation of machines, or planning.

Softwoods: woods from evergreen conifers with needlelike leaves, such as pine or spruce.

Soldering: a process similar to brazing, but generally performed at temperatures below 600F.

Solid model: a computer representation that takes into account both the surface and the interior substance of an object.

Solidifying: the hardening of a liquid or solid material in a mold.

Solvent bonding: a joining process for plastics that uses a solvent to soften the edges of the pieces to be bonded.

Solvent evaporation: the means by which many organic coatings change from a liquid to a solid state.

Specification sheets: written summaries of the characteristics of a product.

Spraying: a finishing method in which paint or similar material is vaporized and deposited on the surface of the material.

Squeezing forces: these forces compress a material to change its shape or thickness.

Staff employees: persons with specialized responsibilities who advise the company's operating managers.

Standard stock: material output by primary processing operations, available in standard size units or standard formulations.

Steam cleaning: the use of steam and detergents to remove grease and oily deposits from the surface of metal.

Stockholder's equity: the actual value of the investors' share of the company. Also called the company's *net worth*.

Stockholders: those who hold shares of stock, representing partial ownership of a company.

Storyboards: a series of sketches showing the sequence of camera shots for a television commercial.

Straight cut machines: equipment that makes straight-line cuts through a workpiece. Straight cut machines can produce only rectangular parts.

Straight turning: machining done by the cutting action of a single point tool to produce a uniform diameter on a rotating workpiece.

Strength: the ability of a material to resist an applied force.

Strike: a refusal by unionized workers to perform their jobs. Strikes usually occur when labor and management fail to agree on a contract.

Subassembly: a component, assembled from separate parts, that in turn is combined with other components to form the finished product.

Surface coating: a finishing process that adds a layer of a different material to the surface of a base material.

Surface model: a computer model in which an object is defined only by its surface.

Surface texture: the way a material's surface looks or feels: smooth, rough, shiny, dull, etc.

Synergism: a state in which the whole effect is greater than the sum of the individual effects.

Synthetic polymers: polymers designed and produced by humans from natural organic materials.

System goals: the meeting of human needs and wants as they relate to this specific system.

Systems drawings: engineering drawings that provide information on the layout of various systems that make up the product.

T

Taper turning: machining done by the cutting action of a single point tool to produce a uniformly changing diameter along the length of a rotating workpiece.

Task setting: the process of setting job requirements.

Technological systems: physical systems consisting of five essential, interrelated elements: inputs, processes, outputs, feedback, and goals.

Technology: the study of how humans develop and use items to change or control the world around them.

Tempering: a process that relieves internal strains in a material that are caused by hardening or other treatments.

Temporary fasteners: devices designed to allow easy removal for disassembly of a product or component. Cotter pins and wing nuts are examples.

Tensile strength: the ability to resist forces that would pull the material apart.

Termination notice: a form used to tell employees that their services are no longer needed.

Test market: a geographic area, considered to be "typical," that companies use to test the appeal of products and the effectiveness of advertising programs.

Thermal conditioning: a process that changes the internal structure of a material through controlled heating and cooling.

Thermal conductivity: a material's ability to conduct heat.

Thermal emission: ability of a material to give off, or *radiate*, heat.

Thermal expansion: the amount that a material expands when heat is applied and contracts when heat is removed.

Thermal properties: characteristics of a material that determine how it will react to temperature change and to heat and cold at different levels.

Thermal resistance: a material's ability to resist melting.

Thermal shock resistance: the ability of a material to resist shock caused by sudden temperature changes.

Thermoforming: a process used to form plastic sheets into trays and other shapes.

Thermoplastic adhesives: polymers that are naturally tacky. They may be suspended in a liquid or formed into a stick that melts at a low temperature. The bond is achieved when the solvent evaporates, or the melted adhesive material cools.

Thermoplastics: synthetic polymers that can be heated and formed repeatedly.

Thermosets: synthetic polymers that resist heat once they are molded.

Thermosetting adhesives: powdered or liquid polymers that cure by either chemical action or the application of heat.

Threaded fasteners: devices that use the friction between two threaded parts, or between threads and the material itself, to hold pieces together.

Tolerance: the amount a dimension can vary and still be acceptable.

Top down system: one in which a program is developed by managers and handed down to the workers to be carried out.

Top management: the persons who make decisions about the day-to-day operation of a company.

Torsion strength: the ability to resist twisting forces.

Trade credit: the delay allowed by suppliers (usually 30 to 90 days) between the time material is purchased and the time it must be paid for.

Trade name: the legal name of a company; the name that identifies a company to its customers.

Trademark: a name, a symbol, or combination of name and symbol used to identify a product.

Transformation processes: processes that change resources (inputs) into outputs, such as products.

Transformation technology: the appropriate use of tools, machines and systems to convert materials into products.

Transportation technology: the use of technological systems to move people and goods from one place to another.

U

Unfair labor practices: tactics that interfere with union-organizing activities.

Union contract: agreement between a company and workers represented by a union.

Union organizer: representative of the national union sent in to help start a local union.

Union security: the level of labor agreement a company has, affecting whether workers must belong to a union.

Union shop: all workers must become union members after a specified period of time.

Union steward: a union official who represents workers in a single department or plant area.

V

Van der Waals forces: a secondary form of bonding important in determining how a plastic will behave: if the bond is strong, the plastic is a thermoset; if weak, a thermoplastic.

Variable path systems: methods of material handling that are not restricted to following fixed routes from point to point.

Variable sequence robot: a robot that can be programmed to do one task, then easily reprogrammed to do a different one.

Varnish: a clear coating material made from a mixture of oil, resin, solvent, and drier.

Vendor: a supplier of materials to a company.

Vestibule training: formal classroom and technical training used before a worker is assigned to jobs of a more complex nature.

Video display terminal: a television-like screen upon which the computer displays information.

W

Wage control: the process of measuring performance against job requirements.

Warm forming: the forming of material at temperature between room temperature and the recrystallization point.

Waste: unusable surplus material resulting from a manufacturing process.

Wildcat strike: an illegal strike called during the life of a contract.

Wire fasteners: mechanical fasteners, formed from wire, that make use of friction between the fastener and the material to hold pieces together.

Wireframe model: a series of lines, arcs, and circles that together form the outline of an object.

Work force: the employees of a company.

Work orders: forms used to direct machine operators.

Work-hardening: a structural change in metal caused by such processes as hammering or rolling.

Working capital: the money at a company's disposal from sales income, stockholder investments, and loans.

Workstations: locations on an assembly line or other operations where workers perform tasks.

World-class product: products of high quality that work well, are easy to operate, and are relatively inexpensive.

Y

Yield point: the lowest point at which a material can be permanently deformed by an applied force.

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